AC 11.66103
20
THE JOHN CRERAR LIBRARY
MAY 26 1937

THE REVIEW

DEVOTED TO THE INTERESTS OF THE AMERICAN SOCIETY FOR METALS

Volume X | MAY, 1937 | No. 5

Western Metal Congress Will Be Held in '38

Los Angeles Will House First Pacific Coast Exposition and Convention Since 1931

One of the important actions taken by the Board of Trustees of the A.S.M. at the meeting in Cleveland on April 30 was to complete arrangements for the third Western Metal Congress and Western Metal Exposition in Los Angeles the week of March 21, 1938.

The first exposition and congress held on the Pacific Coast was in Los Angeles in 1929. It was an outstanding success and was repeated in San Francisco in 1931.

In making arrangements for repeating this western event, the Trustees have in mind not only service to the five chapters of the A.S.M. located on the Coast, but that it will also serve as a meeting point for the western sections of many of the national engineering societies.

The program for the congress will have as its general theme, "Metals in Industry," in which particular attention will be paid to the oil, mining, chemical, and aviation industries, as well as the fabrication and machinability of metals.

The exposition will again embrace exhibits of all of the industries manufacturing materials or equipment used in the metal industry.

The congress sessions will be held at the headquarters hotel, the Los Angeles Biltmore, while the exposition will be held in the new Pan-Pacific Auditorium which has on one level over 100,000 sq. ft. of floor area.

The floor plans for space reservations will be forwarded to prospective exhibitors about June 1.

Three N. Y. Chapters Have Joint Meeting At Cornell University

By K. J. Mackenzie

The joint meeting of the Syracuse, Rochester and Southern Tier Chapters of the A.S.M. was held Monday, April 19, at Cornell University, Ithaca, N. Y.

The afternoon session was held in Baker Laboratory with C. W. Mason, director of physical chemistry, presiding.

Through the courtesy of the Carborundum Company, Francis Bowman, advertising manager, gave a very interesting talk covering the history of the development of silicon carbide and aluminum oxide abrasives. This was supplemented by four reels of motion pictures showing the manufacture and application of these products.

Dinner was served at 6:30 in the Memorial Room of Willard Straight Hall, with Prof. S. C. Hollister, assistant dean of the College of Engineering, presiding. National Secretary "Bill" Eisenman gave a short after-dinner talk in his own inimitable style.

Dr. T. H. Nelson, consulting metallurgist, then presented a paper entitled "A Comparison of the Melter, the Welder, and the Heat Treater," which has already been reported in an earlier issue of THE REVIEW.

Where Metalmen Gather Next Fall

Earnshaw Cook

J. R. Vilella

An Air View of Atlantic City, Site of the A.S.M. Convention Next Fall Shows in the White Circle the Ambassador Hotel, Headquarters for the A.S.M. The long white building above the Hotel and facing the ocean is the Auditorium where the Exposition will be held. Earnshaw Cook and J. R. Vilella will be special lecturers during the Congress.

Nominations for New Officers

In accordance with the Constitution of the American Society for Metals, the Nominating Committee appointed by President Bain met on Monday, May 20, in Pittsburgh.

Those present were George V. Luerssen, chairman, A. B. Beaver, Kenneth H. Hobbie, Carl G. Johnson, Edward G. Mahin, Irving C. Matthews, J. M. Watson.

The following nominations have been made:

***President*—George B. Waterhouse, Professor of Metallurgy, Massachusetts Institute of Technology.**

***Vice-President*—William P. Woodside, Vice-President, Climax Molybdenum Company, Detroit.**

***Treasurer* (2 years)—Bradley Stoughton, Dean of Engineering Department, Lehigh University, Bethlehem, Pa.**

***Trustees* (2 years)**
James P. Gill, Chief Metallurgist, Vanadium-Alloys Steel Co., Latrobe, Pa.
Harvey A. Anderson, Metallurgical Engineer, Western Electric Company, Chicago.

Three Reasons for Testing Metals Are Defined by Thomas at Oregon

Oregon Chapter—Three general purposes for making tests on metals were given by C. E. Thomas, associate professor of engineering materials, Oregon State College, in a talk on April 6.

Tests are made *(a)* to determine fundamental properties of a material, *(b)* to determine its acceptability in the light of a proposed use, and *(c)* to establish reasons for failures in service.

Professor Thomas classified test methods as structural, dynamic, special property tests, and tests of metallic structure.

Under the first classification the tensile test and its commercial applications were reviewed briefly. The compressive test is useful where compressive properties differ considerably, as in cast iron, and where metal is definitely restricted to use under compressive stress, such as bearing bronze.

Torsion tests and their applications to wire were discussed, and it was stated that transverse loading is more useful in a test of the whole structure than of the metal alone.

Repeated stress tests, impact, repeated impact (now little used) and wear testing are tests to reveal dynamic properties.

A great variety of methods can be used for repeated stress tests, of which the rotating beam under uniform bending moment is most favored because of its amenability to high speed operation, and its freedom from the effects of stress concentration.

Wear testing in its present state is most unsatisfactory and is often found not to correlate with actual service.

Tests of special properties include hardness—probably the most generally useful of all methods—abrasion, cupping and cold bend tests, and corrosion tests.

Corrosion testing is a very extensive field because of the varied circumstances in which corrosion is a factor, as well as the variety of metals to consider.

Micrographic analysis, X-ray diffraction, radiography, magnetic, electrical and the new ultra sound method of inspection constitute the tests for metallic structure.

National Metal Expo Expected To Be Sell-Out

90% of Space Already Reserved; Technical Program Includes Carburizing Symposium

With 90% of the available space for the National Metal Exposition to be held in Atlantic City the week of Oct. 18 already reserved, the A.S.M. is again assured of an outstanding, successful meeting.

Over 180 firms have made reservations for the October event, and the plans they are making for showing the new methods and new products will mark the exposition as a real stepping-stone in the progress of the metal industry.

The technical program, under the direction of Assistant Secretary Bayless, is rapidly assuming final form, and judging from the number of papers as well as the outstanding qualifications of the authors, it will be on a par with the previous exceptionally splendid presentations.

One of the highlights of the convention will be a symposium on "Carburizing" which will extend over a period of two days.

The educational lecture course this year will be presented by Earnshaw Cook, research metallurgist, American Brake Shoe & Foundry Co., Mahwah, N. J., on "The Open Hearth." This will consist of a series of five lectures.

The three evening meetings for 1937 will be under the direction of J. R. Vilella, U. S. Steel Corp. Research Laboratories, Kearny, N. J., and will be devoted to "Metallographic Technique."

The Ambassador Hotel will be headquarters for the A.S.M. Rates are as follows:

Singles, with bath—$3, $4, $5, and $6 per day, European plan.

Doubles, with bath—$6, $7, $8, and $10 per day, European plan.

Members are requested to make reservations immediately, sending them to W. B. Coleman, Atlantic City Convention Bureau, 16 Central Pier, Atlantic City, N. J.

York Chapter Acquires New Ashler and Gavel Set

Four years ago, Bill Allen, then chairman of the York Chapter, conceived the idea that a permanent ashler and gavel should be in the possession of the Chapter.

Consequently, he commissioned a wood artist, who secured a block of black walnut from the battlefield of Gettysburg and made it in a beveled octahedral shape, inlaying the surface with a circle of maple wood.

On each of the 16 sides is to be placed a plate bearing the name of a past chairman of the York Chapter and the year of his service.

The woodsmith carved the gavel from a piece of apple wood, also from the same battlefield.

This ashler and gavel have a striking appearance when placed on the chairman's stand during a meeting, and, with six past chairmen's names already occupying places of honor, will be of service for some ten years to come.

THE REVIEW

Published monthly by the
American Society for Metals
7016 Euclid Ave., Cleveland, O.

E. C. BAIN, *President*
G. B. WATERHOUSE, *Vice-President*
W. H. EISENMAN, *Secretary*
W. P. WOODSIDE, *Treasurer*
Trustees
R. S. ARCHER O. W. ELLIS
R. L. WILSON R. L. KENYON
S. C. SPALDING

Subscriptions fifty cents a year; five cents a copy. Entered as Second Class Matter, July 26, 1930, at the Post Office at Cleveland, Ohio, under the Act of March 3, 1879.

RAY T. BAYLESS.....*Editor*
M. R. HYSLOP.....*Managing Editor*

Cleveland, O., May, 1937
Volume X No. 5

Ontario Chapter Prepares Movie on Testing of Metals

In connection with their educational course entitled Physical Testing of Metals, the Ontario Chapter adopted a unique method for demonstrating actual laboratory testing technique. Under the splendid direction of Owen W. Ellis, Director of the Ontario Research Foundation, two series of educational lectures were sponsored by the Ontario Chapter, one series presented in Toronto, the second series presented in Hamilton.

Realizing the difficulties in bringing a lecture group into the laboratory to demonstrate the making of tensile tests, hardness tests and impact tests, it was decided to have a motion picture film made of these processes, and under the direction of Mr. Ellis, the Associated Screen News of Toronto made the motion picture in the laboratories of the Ontario Research Foundation. This motion picture, in conjunction with Professor H. D. Churchill's five lecture course presented during the Cleveland Convention of the Society last fall, was the broad basis of the course which was augmented by Mr. Ellis.

The film turned out so splendidly and was so informative that it was shown on the first, third and fifth lectures, thus really bringing the group into the laboratory each lecture. The film requires approximately twenty minutes for projection, and is of the 16 mm. size.

The Society's Committee on Visual Education, under the chairmanship of Professor George B. Waterhouse, feels that the Ontario Chapter should be given much credit for pioneering in this form of educational work.

The Committee sincerely hopes that this is the beginning of a series of such pictorial demonstrations that may be adopted by the chapters of the Society in assisting in the presentation of educational courses to its members. Motion pictures of laboratory techniques, laboratory stunts, animated drawings of metallurgical principals might be subjects for consideration.

A copy of the Ontario Chapter's film on the Testing of Metals is available through National Headquarters of the Society and can be had by any chapter gratis by sending a request to 7016 Euclid Avenue, Cleveland, Ohio.

Materials for Helical Coil Springs Are Hard Drawn Wire, Oil Tempered Wire, Valve Spring Wire and Music Wire

Heat Treatment of Wire and Its Manufacture Into Springs Are Explained by Zimmerli; Earle Smith Presents Rapid-Fire Review of European Steel Making Industries

By A. J. Dornblatt

Washington Chapter—A rapid-fire review of his impressions of the European steel making industries was presented by Earle Smith, chief metallurgist for Republic Steel Corp., as a dinner speech at the meeting on Feb. 8.

At the conclusion of the dinner, W. J. Jeffries was presented with a grindstone as a birthday token and in recognition and appreciation of his services to the Chapter as chairman of the Program Committee.

F. P. Zimmerli of Barnes Gibson Raymond then opened his talk on "Springs" by explaining that the materials used in making helical coil springs include hard drawn wire, oil tempered wire, valve spring wire, and music wire.

A process widely used in the manufacture of wire is "patenting"—a quench and draw or delayed quench performed while the wire is pulled through the furnace and lead or coke bath. Its purpose is the production of a "sorbitic" or fine pearlite structure which will draw uniformly in the dies. A lamellar pearlite, Mr. Zimmerli explained, gives a cuppy fracture; a spheroidized material will not draw to an even diameter.

Hard drawn S.A.E. X1065, for example, is passed through a furnace maintained at 1800° F. and thence into lead at 1000° F. Such wire after four equal percentage reductions to size .105 will show a tensile strength of 225,000 to 240,000 psi. and bend on its own diameter.

S.A.E. 1065, with lower manganese, is used oil-tempered by quenching from a lead bath at 1550 to 1600° F. into oil at 120 to 130° F. This grade of wire will show a tensile strength of 229,000 to 249,000 psi.

Valve spring wire is a 0.65 to 0.70% carbon Swedish rod or equal quality material with less than 0.025% phosphorus or sulphur. It is drawn through carboloy dies to afford a satin smooth finish, and exhibits a tensile strength of 205,000 to 210,000 psi.

Music wire is S.A.E. 1095 material. Rod 0.312 in. diameter is air patented at 1800° F., passing through a coke bed to prevent oxidation.

Cleaned, pickled wire is given a copper coating by immersion in copper sulphate solution, drawn two passes and then tin coated by passing through a stannous chloride solution containing brewery mash. It is then drawn three or four holes to size .105. The thin tin or copper coating acts as a lubricant in the wire-drawing process.

Large helical springs are now being made of S.A.E. 9260, X1035, and 6150 steels. The wire is ground to tolerances of about two thousandths, heated, coiled on a mandrel and quenched while on a jig in oil, then drawn to about 283 to 300 Brinell by heating about 1 hr. at 850° F.

Helical springs are not as subject to extraneous stresses as other designs and will outlast other types eight to ten-fold.

Progress in springs, says Mr. Zimmerli, has been tied up with the use of carboloy dies and finely ground wire to reduce surface imperfections.

Coating the wire tends to reduce scratching. The endurance limit of stretched wire is frequently only 60 to 65% that of wire with a polished surface.

Since fatigue failure of springs begins at the surface skin, or the most highly stressed part, any method of raising the strength of this surface will be somewhat beneficial and both nitriding and cold work are used.

New York Meets With Welding Society April 19

By J. Z. Briggs

New York Chapter's annual joint meeting with the New York Section of the American Welding Society was held on April 19.

Technical chairman C. W. Bryan, Jr., vice-president of the Federal Shipbuilding and Dry Dock Co., and chairman of the New York Section of the A. W. S., introduced Everett Chapman, president of Lukenweld, Inc., who spoke on "Stresses in Welded Joints and Their Elimination."

Mr. Chapman's excellent lecture has already been reported in THE REVIEW. After the lecture, the members of both societies enjoyed some liquid refreshment.

Alloying Confers Certain Properties On Copper Base

By Emerson S. Norris

Baltimore Chapter—Metals are added to copper not to make cheap alloys, but to make engineering alloys retaining certain properties of the copper base at the expense of other properties, according to R. A. Wilkins, vice-president and director of research, Revere Copper and Brass, Inc., at the meeting on April 12.

Dr. Wilkins talked chiefly on the processing of the common copper alloys, explaining their treatment in the shop and the resulting properties of the alloys.

Such alloys are exemplified in the common brasses. Alpha brass retains a great deal of the cold ductility and corrosion resistance of copper and gains strength. Alpha beta brass is stronger than alpha brass but sacrifices corrosion resistance and ductility.

Grain size has to be closely controlled in all fabrication processes. For example, in phosphor bronze springs the grain size of the original stock affects the modulus of tensile resiliency of the finished spring.

Hot rolled rods have very different properties from extruded rod—a difference directly traceable to microstructure. The front end of an extruded rod retains the original cast structure of the ingot, and the structure progressively changes over the length of the rod until at the rear a characteristic hot worked structure is obtained.

Alloys containing 3% silicon plus small amounts of other metals have proved very useful and popular. They possess high strength, weldability, and corrosion resistance, but can at times be quite untrustworthy at elevated temperatures under stress in the presence of corrosion media.

Production of condenser tubes has received considerable attention and has led to great advances in the processing of that type of article.

Many alloys do not lend themselves to the ordinary Mannesmann piercing process for tubes, and are fabricated in other ways, such as cup drawing, forming a cylinder by extrusion followed by rolling, and starting with a cylindrically cast ingot.

DO YOU KNOW THAT

● THAT . . . 3900 locomotives would be needed to move the 27 million tons of steel contained in the buildings and transportation facilities in service in the 22-sq.mile area of the island of Manhattan?

* * *

● THAT . . . steel springs which tip the scales at only 12 millionths of a lb. each are the smallest and most expensive product of the steel industry? These delicate aristocrats of the spring family are used in jewelry and calculating machines.

* * *

● THAT . . . the average life of steel used in this country is now 32 years or more than twice as long as it was 50 years ago?

* * *

● THAT . . . in many steel mills today 30% of the personnel is composed of young men with less than one year's experience? And that this 30% is responsible for about 75% of all the accidents occurring in the plants? Just another problem engendered by depression and subsequent recovery!

* * *

● THAT . . . industry's 1937 appropriation for research will exceed $250,000,000, according to estimates by President E. R. Weidlein of the American Chemical Society? The steel industry alone spent $9,200,000 on research in 1936, 6% more than was spent in 1929.

* * *

● THAT . . . the American Society for Metals had the smallest number of members dropped on April 30 (after the annual March billing) for non-payment of dues in its history? Bang goes another record!

Bonded Carbide Practice Here and Abroad Given

By B. F. Anthony

Mahoning Valley Chapter—At the April meeting Chairman Goss presented the slate of nominations for next year's officers, and it was moved and accepted that the nominees be considered the Chapter's governing body for the next season.

Dr. Zay Jeffries was then introduced to the assembly and delivered an excellent talk on "Bonded Carbide" cutting materials.

He discussed prevailing practices in Europe and America, the trends in machining and machines using the carbide tools, and the various compositions such as the tungsten, tantalum, titanium, boron and vanadium carbides.

Phillip McKenna ably commented on the paper and several members joined in the ensuing discussion.

Bronze at the Beach

Beach fashions should be interesting even to metallurgists when it is discovered that the ultra-modern one fit at the left is made of non-rusting bronze mesh.

The suit was manufactured by the Whiting & Davis Co. of Plainville, Mass., and the material (satin lined) can be purchased for the paltry sum of $18 a yard.

Lecturers and Class, Southern Tier Course

Principles of Heat Treatment Was the Subject of the Course That Drew This Attentive Audience in the Schoolhouse of International Business Machines Corp., Endicott, N. Y. Dr. G. B. Briggs, dean of the I.B.M. school, is shown at the left addressing the group. Third from the left and seated is L. C. Conradi, I.B.M. technical research director and a director of the Southern Tier Chapter, who was the instructor for the series of four lectures.

Former Chairman and Expert on Grain Size Returns to Detroit as Speaker

By Howard E. DeHaven

Detroit Chapter—A former chairman of the Detroit Chapter returned on April 12 to discuss informally the fundamentals of "Grain Size, Normality and Hardening of Steels." He is H. W. McQuaid of Republic Steel Corp., Massillon, Ohio.

In order to make clear what was meant by grain size, several different kinds of grains were shown, among which were a fractured overheated forging, a broken axle shaft, a carburized piece at low magnification with a fine case and a coarser core. At higher magnification a carburized sample was shown, in which the grains in the case were outlined with cementite.

Hardenability of a given steel depends upon the amount of carbon in solution and its distribution. This is determined by the type of structure in the piece at the time of quenching and the structure in turn depends upon the relative size of the carbides and the rate at which they dissolve and diffuse in the form of carbon.

For maximum hardenability the carbides must be completely in solution and uniformly diffused throughout the grains and across the grain boundaries.

Grain Size Not Controlling Factor

Grain size is not the controlling factor in hardenability as is shown by the fact that some coarse-grained steels may be shallow hardening and some fine-grained steels, deep hardening. If the steel is heated high enough to get complete solution, with the grain borders carburized, the grain coarsens and hardenability increases.

Normality is an indication of the ability of the carbides to resist coalescence and therefore, in normal steels, the carbides exist in finely divided plate form with an apparent increase in the amount of fine pearlite for a given carbon content.

For most applications a fine-grained abnormal steel with alloy additions gives sufficient hardenability at the surface and a lesser hardness at the center, reducing internal stress.

Figures were shown indicating that differences in impact properties of plain carbon steel, even when heat treated at as low a temperature as 1500° F., could be predicted from the difference in results after carburizing at 1700° F.

Compliments

To **Penton Publishing Co.** on the selection of **E. L. Shaner**, editor of *Steel*, to be president of the company.

-*-

To **The Carborundum Co.** and to **Francis Bowman**, capable and efficient advertising manager, upon the completion of the 11th successful season of broadcasting.

-*-

To **Marc Grossmann**, chief metallurgist, Chicago District, Carnegie-Illinois Steel Corp., on the sell-out of the first edition of his book, "Principles of Heat Treatment," and his splendid revisions for the second edition.

-*-

To **Henry Disston Steel Works** on having selected **J. M. Goodpasture** to have complete charge of the Tool Steel Dept.

-*-

To **Bethlehem Steel Co.** in consideration of the splendid impression made by **C. H. Herty, Jr.** in his talks before the York and Penn State Chapters, A.S.M.

-*-

To **Frank H. Adams**, vice-president and general manager of Surface Combustion Corp., on his 25th anniversary with the Henry L. Doherty interests.

Hotel Rates for Atlantic City Show Are Reasonable

Members should not get the wrong impression about hotel costs in Atlantic City during the National Metal Congress and Exposition.

While Atlantic City has an outstanding reputation as a resort and health city, it is, beyond that, probably one of the best convention cities in the United States.

During the A.S.M. convention (Oct. 18 to 22) the busy season for the hotels as well as the beach will be over and the winter rates, which are lower than the summer rates, will be in effect. In addition, members of the Society will secure a "convention rate," which is $1.00 per room lower than the winter rate.

The June issue of *Metal Progress* carries a list of the hotels and their rates. Single rooms with baths may be obtained at Boardwalk hotels from $2.50 up; double rooms start at $4.00.

In addition to European plan, many hotels also offer rates on the American plan (three meals a day) for from $2.50 to $4.00 per day extra.

At the Ambassador Hotel (headquarters for the A.S.M.) special club breakfasts, luncheons and dinners will be served; beginning prices are 50c for breakfast, 85c for luncheon, and $1.25 for dinner. Room rates are $3.00 up for singles and $6.00 up for doubles.

You may be assured that you will be able to attend the convention in Atlantic City at as reasonable a cost as for any other city in which the convention might be held.

Brass Forging Is Featured

By T. P. Black, Jr.

Peoria Chapter—A talk on the forging of brass and bronze featured the technical program at the monthly meeting on April 12.

Speaker was H. P. Croft, chief metallurgist of Chase Brass & Copper Co. and chairman of the Cleveland Chapter—a man well qualified for such a lecture and one with wide experience in copper and brass products. His talk was well illustrated with slides and proved of exceptional interest.

The Peoria Chapter extends best wishes to the Cleveland Chapter and hopes to have Mr. Croft come again sometime in the future.

Mo Production Was Tripled In Depression

Mo Automotive Steels, Government Study and Use in Tool Steel Caused Increase

By J. W. McBean

Ontario Chapter—With the authority of an impartial observer, H. W. Gillett, technical adviser to Battelle Memorial Institute, Columbus, Ohio, spoke on molybdenum in ferrous metallurgy at the April meeting in Toronto.

A brief account of the history of molybdenum told of the discovery of the Colorado and New Mexico deposits during the War and the slump in the industry following the War.

In 1926 the S.A.E. 4100 steels were developed for motor cars, serious study was given to molybdenum by the Watertown Arsenal and the U. S. Navy, and these factors, combined with the later work of Emmons on molybdenum high speed steels, increased production during the depression to three times that of 1929.

Useful for High Temperatures

Since molybdenum itself is hard and strong at high temperatures, it endows steel also with hardness, strength, and creep resistance. This leads to a great variety of uses, including high speed tools, valves and valve inserts for gasoline engines, oil cracking and power plant piping, and die blocks.

Molybdenum behaves much like tungsten in high speed steel, but the cost is considerably less than that of the standard 18-4-1. Like tungsten, molybdenum requires a high quenching temperature, but it is usually about 150° F. lower than that of 18-4-1, which is a distinct advantage.

One of the useful properties conferred by molybdenum, even in small amounts, is the power to eliminate or reduce temper brittleness found in nickel, chromium and manganese steels on slow cooling from the tempering temperature and also in nitriding steels.

Has Cooperative Effect

Molybdenum has the fortunate property of increasing the desirable effects of a number of other alloys when used with them. The amount required is usually quite small, about 0.2 to 0.6%.

In the medium manganese steels ductility and impact resistance are greatly increased and 0.4% Mo added to rails of this type is said to double the life.

In the 4100 chromium-molybdenum steels, the depth hardening effect of the chromium is increased by molybdenum. In the nickel-molybdenum carburizing steel S.A.E. 4615, the case hardness and core toughness are very good with a single quench.

A striking example of the cooperation of molybdenum with other elements is the fact that when it is present phosphorus can be used as a strengthener without producing cold shortness. In the "Mola" steel grain size is kept fine by using aluminum and shallow hardening prevented by adding 0.5% of molybdenum.

The slow critical cooling rate of molybdenum steels which produces air hardening has sometimes to be counteracted by reducing the carbon and other alloys. With the X4130 steel for aircraft tubing, however, in the thickness used, the air hardening is just enough to give the desired combination of strength and ductility on cooling after welding, and as before mentioned, the molybdenum makes for easy welding.

Molybdenum tends to produce fine graphitic flakes in cast iron and uniformity of properties in large sections.

Resistance to corrosion by sulphides in the 20% Cr, 9% Ni alloy is increased by the addition of 2 to 4% Mo.

X-Ray Analysis, Interpretation Given by Goss

X-Rays Discovered Early But Laue's Crystal Diffraction Ideas Not Voiced Till 1912

By A. J. Dornblatt

Washington Chapter — A graphic demonstration of applications of X-ray analysis and interpretation of X-ray photographic patterns by Norman P. Goss of Cold Metal Process Co. at the meeting on March 8 intrigued the audience, many of whom were familiar with Mr. Goss's X-ray studies.

Mr. Goss reviewed briefly the early history of X-rays. Although discovered in 1895 by Roentgen, it was not until 1912 that the property of diffraction of X-radiation by crystals was predicted by Laue.

With this discovery and the theory of space-groups perfected by Schoenfluss, the location of the atoms, even in the space lattice of complicated structures, and the lattice parameters could be accurately determined.

Slides Illustrate Asterism

A number of slides illustrated the fact that asterism and other irregularities in the diffraction effects are associated with imperfections in the crystals, and not lattice distortion, as is often thought. For instance, Jeffries and Bain in 1921 proved that when a single crystal is deformed, a mixed orientation is developed, and the appearance of the diffraction rings proves this.

The speaker had proved in 1928 that the appearance of asterism on X-ray diagrams of deformed metals proves that rotation of the crystal fragments has occurred. Previously—and even at this time—many associated asterism in Laue diagrams of deformed metals with bending of the lattice planes (curvature).

Block Structure Is Complex

A Laue diagram made of what was believed (in 1928) to be a single crystal was found to be built up of smaller units called "blocks." Other Laue diagrams were shown to illustrate the complexity of the block structure, or fine structure of the grain. When the blocks are only displaced slightly from each other there is produced a mosaic structure; when the displacement is several degrees, the structure is fibrous.

Vector methods may be used in determining the orientation of the crystal fragments in cold rolled strips. Using a 0.006-in. pin-hole to enable high resolution, an iron-silicon alloy given an area reduction of 94% was found to have a double orientation fiber.

X-Raying in Several Directions

A simple precaution, frequently overlooked, is the X-raying of a given specimen in several directions. A 0.55% C steel given an area reduction of 50% only showed an orientation structure in the T-direction and random orientation in the other directions. Heating this below A_3 developed a new orientation, and heating above A_3 produced a random structure.

X-ray diagrams showing the differences in the development of fiber structure in cold-drawn wires and hot-rolled rods were then explained. Another series of diagrams illustrated how difficult it sometimes is to remove preferred orientation from high carbon wires given area reductions in excess of 35%.

The complicated orientation structures found in hot-rolled alloy strips are very difficult to remove by heat treatment.

A.W.S. Manager

Warner S. Hays

The selection of Warner S. Hays as managing director of the American Welding Society is part of the program adopted by the Directors to serve better the members and the welding industry.

Mr. Hays brings to the Society an unusual combination of experience and background in engineering, sales, publishing, membership development and association management. He is a past president of the American Trade Association Executives, a member of the Philadelphia Rotary Club, the Yale Club of New York, is on the Executive Committee of the Yale Engineering Association, and is a former officer of the National Industrial Advertisers.

An electrical engineering graduate of Yale's Sheffield Scientific School, Mr. Hays was employed successively by General Electric Co., the Interurban and Traction Lines of Rockford, Ill., the Light, Power and Traction Lines of DeKalb and Sycamore, Ill., and the McGraw Publishing Co. in New York. Since the War Mr. Hays has maintained his own consulting, engineering and association executive office in Philadelphia.

Janitzky Untangles Stress and Strain And Tensile Test

By Merrill A. Scheil

Milwaukee Chapter—The interrelation of stress and strain as it manifests itself in the tensile test was discussed by Emanuel J. Janitzky, consultant metallurgical engineer, Carnegie-Illinois Steel Corp., who spoke on "Mechanical Properties and Machinability of S.A.E. Steels" on March 25.

In discussing the relationship of mechanical properties to machinability, Taylor's cutting efficiency for 60 minutes was used as the index of machinability.

Mr. Janitzky showed a series of curves comparing Taylor's cutting speed with tensile strength, yield point, Brinell hardness, elongation and reduction of area. In all these curves carbon steels and austenitic steels separated themselves from alloy steel.

However, Janitzky finds that Taylor's cutting speed shows a better relationship with the ratio of Brinell hardness to reduction of area, and presented a family of curves which held for both carbon and alloy steels.

The relationship does not hold for cold drawn material unless the reduction of area and Brinell hardness before cold drawing, as well as the decrease of reduction of area after cold drawing, are known.

In the discussion that followed, S. L. Hoyt suggested that Meyer's P_m number could be substituted instead of the Brinell hardness number, because the Brinell number is not a true physical measurement.

Hoyt also suggested that n in the Meyer's analysis $P_m = ad^n$ might even be more appropriately used in the formula for V_m, since it is more closely associated with machinability.

"Cavitation" Is Mechanical or Impact Effect

Corrosion Plays Small Part, Says Mousson, Giving Account of Thorough Research

By Emerson S. Norris

Baltimore Chapter—"Cavitation," a subject of great importance yet little understood, was discussed at the March meeting by J. M. Mousson, hydraulic engineer of the Pennsylvania Water & Power Co.

His fine talk was based on the results of research work conducted by his company at the Holtwood Power Station on the Susquehanna River.

A thorough investigation of the causes of and cures for failures due to cavitation was undertaken with special reference to turbine and pump failures. Equipment to make accelerated tests on alloy specimens was devised, and a large number of tests made. The time of test was 16 hr.

Cavitation is the formation of water vapor in liquid water due to the local reduction of pressure caused by a propeller cutting through the water or by the flow of water through an orifice. Restoration of normal pressure results in the collapse of the cavity, which sets up terrific impact forces, which in turn are transmitted to the adjacent metal.

The impact frequently causes serious damage by pitting and eventual loss of metal. Cavitation is almost entirely a mechanical failure, corrosion playing usually a minor part.

Results of the research show that within the range of seasonal water temperature available, cavitation loss increases proportionally to the vapor pressure.

Injected air decreases loss and the effect of air is greater at low velocities of the water. Because of its cushioning effect, air reduces vibration.

In a 16-hr. test the number of blows striking the test block runs into the hundreds of millions. Actual deformation takes place and microscopic examination shows that bits of metal are torn from the surface.

Fatigue cracks and cold-worked metal on the surface are characteristic of cavitation failures. In the case of austenitic alloys, twinned crystals are often formed.

The alloys which will resist fatigue and plastic deformation should be the most resistant to cavitation failure and this is found to be correct.

Roughly, the higher the Brinell hardness the less the loss. Ability to harden by cold work increases resistance; also the smaller grain size the better the resistance.

Non-metallic inclusions and, in the case of cast iron, graphite flakes have the opposite effect.

Tests have been made on welds and some work has been done on the failure of metals under strong jets of water.

Open Hearth Plays Prominent Role With Increasing Demand for Quality Material

By David R. Howerton

Chicago Chapter — At the March meeting a large and congenial crowd gathered at the Medinah Club for a dinner preceding the business of the evening.

Following the dinner, for a brief period of entertainment, a wizard at intellectual retrospection and mental gymnastics baffled the older minds of the Chapter and confused the younger ones.

L. F. Reinartz, works manager, American Rolling Mill Company, previously announced as the speaker for this meeting, was unable to address the Chapter. In his absence, G. D. Tranter, general superintendent, Middletown Division of American Rolling Mill Co., lectured on the ever-interesting subject, "Basic Open-Hearth Practice and Design."

The past history of the open hearth was briefly discussed, and Mr. Tranter pointed out that with the demands for higher quality material increasing constantly, never before has the open hearth played a more prominent role.

Training Is Important

Many plants in recent years have done much to modernize their furnaces and improve the melting technique. Training of the furnace and pit personnel has also been a very important feature in the improvement of open-hearth operations. The close cooperation of the melter and metallurgist working together combines the practical experience of the operator with the technical knowledge of the staff and has done much toward the development of high quality steels now in demand by the trade.

The lecturer presented many interesting slides illustrating modern furnace installations with newly designed methods of insulation, labor-saving devices to eliminate many of the hard, disagreeable features of the work, together with methods of regulation and control of furnace operation.

National Officers Visit Tri-City Chapter in April

By R. H. Lind

Tri-City Chapter—Dr. E. C. Bain and W. H. "Bill" Eisenman, national president and secretary, respectively, of the A.S.M., honored the Chapter with a visit on April 13.

Dr. Bain spoke on "Apparent Anomalies in the Hardening of Steel." He presented with a series of slides a most interesting and instructive talk on the concepts of hardenability, revising these concepts as originally set forth in his Campbell Lecture.

Dr. Bain's complete and practical discussion was indeed well received.

Mr. Eisenman presented a brief résumé of national activities interspersed with the typical Eisenman wit and humor. He not only told of the growth of the Society to the commanding total of nearly 10,000 members but also told of the growth of livestock on his farm which he apparently attends to on those few occasions while relaxing from Society affairs.

Ludlum Movies at Dayton

By Richard R. Kennedy

Dayton Chapter—An interesting film entitled "Hunting Big Game of North America" was shown in place of the usual coffee talk at the April meeting conducted by the Ludlum Steel Co.

A. W. F. Green, metallurgist for Ludlum, showed a second film on "The Saga of Fine Steels" and described the pictures as they appeared on the screen. The film depicted the processes of making tool and high alloy steels.

Mr. Green concluded the program with a short talk in which he traced the development of high carbon, high chromium steel and compared its properties with those of high speed steel.

Behavior of Metals Under Static Load

By William J. Diederichs

"Metals—How They Behave in Service" Is the Title of the Lecture Course Presented by the Philadelphia Chapter of the A.S.M. Last Winter. This is the first lecture in the series of six. The others will be presented in subsequent issues of "The Review."

TO LAY A CERTAIN amount of groundwork for the present discussion and possibly some of those which are to follow in this series, a few definitions and a discussion of some fundamental conceptions are in order.

Loads are the external forces applied to a part. We consider a static load one in which the force is applied comparatively slowly and, after application, is comparatively steady. To be precise, true static loads are rather rare; off-hand I can think of only one—a bolt pulled up tight. In most other cases usually considered as static loading, the loads fluctuate more or less.

Loads are of various kinds, depending on how the forces are applied to the piece. You are familiar with the common ones such as: (a) Tension—a pull on the part, (b) compression—a push on the part, (c) transverse—tending to bend the part, and (d) torsion—tending to twist the part. Moreover, the loading on a part may be combinations of any two or more of these.

The effect of an applied load on a part is to change its shape or deform it. The change in shape or the deformation under usual loadings in practice is slight and requires precise measurements to find. Each kind of load results in an appropriate deformation. In tension, the part elongates in the direction of the pull and the cross-sectional area decreases. In compression, the results are reversed. Sufficient transverse load results in noticeable bending and torsion load results in noticeable twisting.

Interatomic or intermolecular forces resist the tendency of the applied loads to deform the material and these internal resisting forces are called stresses. These internal stresses are also the means by which one part of a body transmits forces or loads to another part. You are all familiar with this action. You all know that if I push downward on the top of a pointer stick while the bottom end rests on my toe, I am conscious of the force applied by my hand at the top because of the pressure developed on my toe at the bottom. The force has been transmitted through the stick. A crude mechanical conception of what is going on may be appropriate. Imagine that there is a free spring, inconceivably small to be sure, spanned between each atom and every one of its neighbors. As this atom is moved by any applied force it will place in compression springs ahead of its direction of motion and in tension springs behind its direction of motion. The springs whether in tension or compression will be acting to return the atom to its original position and themselves to free length. But, while "out of position," an atom will be exerting forces on all neighboring atoms and these in turn upon other atoms until the force is transmitted through the member.

Imagine that a bar is held vertically in a vise and that you apply a downward force F (Fig. 1) at its top. This force is transmitted through the bar to the vise jaws. Cut off the bar at X as shown, removing the top portion, and the internal stresses transmitting this force will be acting downwards.

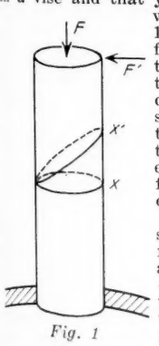


Fig. 1

Suppose that instead of applying a force downward we apply one sideways, $-F'$. It is obvious that if the bar were now cut off at X, the force would have a tendency to slide the top portion to the left. This did not happen, however, when the force was applied to the solid bar, so it is obvious that the sliding tendency was resisted.

Now suppose we cut the bar at an oblique angle as at plane X'. You know from experience that a direct downward force, such as F, will cause the top portion to slide along the oblique plane and move downward and towards the left. No inanimate object moves in any direction unless a force or combination of forces is acting in that direction.

It is important to note here that one of the results of a directly longitudinal force is the development of stresses acting at an angle to the applied force. The same result follows in case "pull" instead of "push" were applied except that the direction of action of the stresses would be reversed.

A study of the stresses acting upon an analysis plane passed through a loaded member will show that, except for planes of special location, stresses are acting perpendicular to the plane, and across the face of the plane, or, in other words, tangential to it. The former are known as normal stresses and are obviously tensions or compressions tending to cause change of length. The tangential stresses are called shear stresses and tend to cause sliding or slipping.

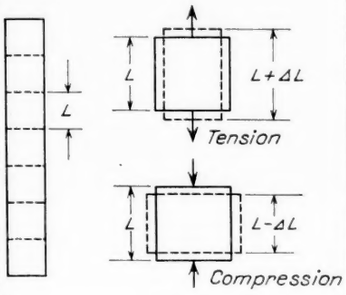


Fig. 2

Let us discuss for a moment the deformations accompanying such stresses. Imagine a square bar in tension and that we divide it into cubes by imaginary analysis planes. The result of the tension stressing as noted on any of the side faces of the cubes would be to lengthen them slightly and to an even lesser extent decrease their width. Compression would reverse these results. Sketching an original cube face in solid lines of length L, the final shape may be sketched in by dashed lines (Fig. 2).

The original length L has been changed by an amount $\triangle L$, either increase or decrease depending on the type of stress involved.

Suppose that the original bar were in tension and it were N cubes long. Then:

Original length of bar = N (L)
Final length of bar = N (L plus $\triangle$L)
Total change of length = N ($\triangle$L) = number of cubes times length change of each cube.

$$\text{Change per inch} = \frac{\text{total change}}{\text{original length}} = \frac{N\ (\triangle L)}{N\ (L)} = \frac{\triangle L}{L}$$

The value so computed by dividing the total change in length of a bar by the original length is known as unit deformation. Note that its dimensions are inches per inch and that if the division is made the result is an abstract number; a ratio. If you divide any value expressed in a definite unit by another value expressed in the same unit, you arrive at an abstract number and the unit used in setting up the ratio has nothing to do with the final answer. Note also that the ratio of change of length to length is independent of length. No definite length is indicated and the method of computation is not dependent upon the original length. Obviously, cross-sectional dimensions are also not involved in this evaluation. Such an abstract number may be expressed as a percentage. For instance, values obtained from a material test might be

$$\frac{\text{Change of length}}{\text{Original length}} = \frac{\triangle L}{L} = \text{say, } \frac{0.2 \text{ in.}}{2.0 \text{ in.}} = \frac{1}{10} = 0.1 = 10.0\%$$

and such a value is a characteristic of the material.

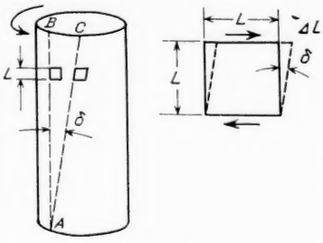


Fig. 3

Let us next consider a round bar held at the bottom and twisted at the top as shown in Fig. 3. As will be indicated later, shear stresses are developed in cross-sectional planes.

You are probably familiar with the fact that if before twisting, a line such as AB is scribed on the surface parallel to the length of the bar, it will, after twisting, have moved to a position such as AC at an angle, say $\delta°$, to its original position AB. A cube face of length L such as that shown at the left will have taken the position shown to the right. Sketching an enlarged view of this cube face we note that it has become "skewed".

The deformation of the face of this cube has been $\triangle$L as shown in the sketch. Geometry and trigonometry indicate that this deformation is

$$\triangle L = L \tan \delta°$$

Now, again, the unit deformation is equal to the total deformation divided by the original length involved, or

$$\frac{\triangle L}{L} = \frac{L \tan \delta°}{L} = \tan \delta°$$

Tangents are ratios and their values, as explained, are abstract numbers, as a glance at any table of trigonometric functions will show you. As before, the value of unit deformation so obtained is independent of the length, may be expressed in percentage and represents a characteristic of the material.

Now, having noted the means of evaluating deformations, let us note the means of evaluating stresses, the internal forces set up to resist the deformation. We will consider only tension loading. The measurement of stress is stress intensity, or unit stress. It is evaluated usually by dividing the total force applied by the original area of the material resisting the effect of the application of that force.

$$\frac{\text{Force (load) in lbs.}}{\text{Original area in square inches}} = \frac{\text{pounds}}{\text{sq. in.}} = \text{psi.}$$

For example, suppose a load of 100,000 lbs. is applied, say by suspension, to a bar 2 in. square. Then the intensity of stress in tension, or unit tension stress developed because of the application of this load is

$$\frac{\text{Load}}{\text{Area}} = \frac{100{,}000 \text{ lbs.}}{4 \text{ sq. in.}} = 25{,}000 \text{ psi.}$$

If the same load were applied to a 1 in. square bar we have

$$\frac{100{,}000 \text{ lbs.}}{1 \text{ sq. in.}} = 100{,}000 \text{ psi.}$$

and, if it were applied to a 5 in. square bar, the stress intensity becomes:

$$\frac{100{,}000 \text{ lbs.}}{25 \text{ sq. in.}} = 4{,}000 \text{ psi.}$$

Note that the method of evaluating the stress intensity eliminates from consideration the actual area involved. Obviously also, length is not involved in the evaluation.

The strength of a material is the stress intensity which will cause failure in some definite manner. This failure need not be rupture; it may be one of excessive deformation. However, the values for "strengths of materials" usually reported are those obtained from a tension test and indicate the maximum stress which the materials are capable of sustaining prior to rupture.

It has been shown that evaluations of unit deformation and unit stress are so made that over-all dimensions of the member are eliminated from the picture. It has been indicated that stresses and deformations are inter-related, and, if this relationship is established using unit values of stress and deformation, it will be characteristic of the material as such, and not a characteristic of size and shape.

This is true until permanent deformations, which will be discussed later, particularly localized deformations, occur. Because tests are usually carried beyond the point of permanent deformation, or even to rupture, it still is necessary, if comparisons between tests are to be made, to make the test specimens to definite standard shapes.

A picture of this relationship is the familiar stress-deformation, more frequently called stress-strain diagram, Fig. 4, page 6.

I would like to digress here for a moment. The word strain has not been used throughout this discussion and barring a slip of the tongue, will not be used. It happens that the engineer uses the word strain with a very particular meaning. He *always* means deformation when he says strain. Unfortunately, it is perfectly good English in other than engineering discussions to use strain to imply effort, force or stress and so the engineer using the word strain may be misunderstood. For instance, you will hear a person say "I am working under pressure, or stress" and another "I am working under a strain"; both inferring the same thing. For greater clarity, therefore, I have chosen to use the word deformation in preference to strain though it is the longer of the two.

The Stress-Strain Diagram

Data for the curve of such a diagram are obtained by subjecting a sample of material to some one of the standardized test procedures. For instance, a tensile specimen of known diameter may be gripped to permit pulling it in a machine equipped to measure at any desired time the pull in pounds, i.e. load, which is being applied. An accurate device for measuring the distance between gage points, a known distance apart, on the specimen is applied. A load is applied and the load and resulting length between gage points is recorded. At each increase in load, values of load and length between the gage points are recorded and this is continued until the test is completed. There results, therefore, a series of readings showing load values and simultaneous length values. These may be used to determine for each stage of the test simultaneous values of unit stress (psi.) and deformation (inches per inch, or percentage), and these simultaneous values may be plotted on coordinate paper to a vertical scale laid off in psi. and a horizontal scale laid off in inches per inch or percentage (illustrated by sketch) and there results the familiar diagram.

It may be well in passing to mention that during such a test the load or force in lbs. is moving in the direction of its application for a distance represented by the stretch of the specimen. Work is defined as force acting over a dis-

Behavior of Metals Under Static Load

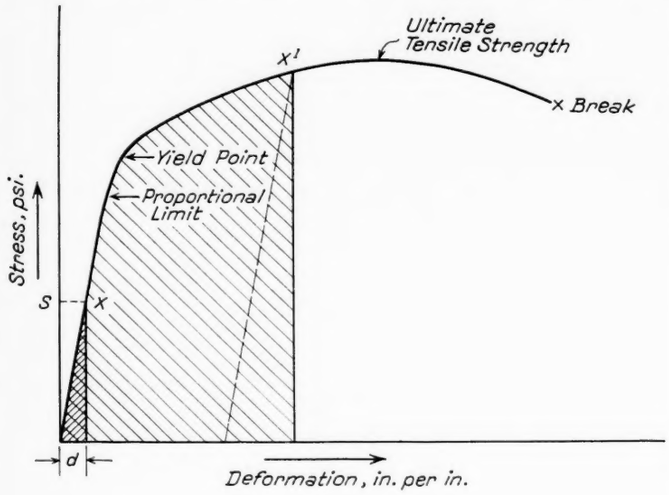


Fig. 4

tance in the direction of its application. For instance, in applying a pound force to a body to move the body one foot in the direction of the applied force means that one ft-lb. of work has been done. Work is being done upon the material during such a test, the amount depending upon the forces required and the particular stretch of the sample. Have you ever tested to destruction a ductile material in a hand operated testing machine where the work is supplied by yourself in turning a crank? If so, you will not doubt the work requirement.

In the case of wrought steels, and wrought materials in general, it will be noted that during the early stages of load application, the deformation increased in direct proportion to the load: i.e. if at 5,000 lbs. load we find an elongation of d in., at 10,000 lbs. the elongation will be $2d$ in., at 15,000 lbs. $3d$ in., etc. This means that for a time the stress is proportional to deformation. How far this proportionality continues depends upon the material. In the case of castings, stress and deformation may be proportional for comparatively low stress values, or possibly not at all.

There has been sketched a generalized form of stress-deformation diagram. It will serve to illustrate other items of interest to be discussed. Such diagrams may be of various forms, showing high or low proportionality, high or low strength, with or without large values of deformation, and the change from proportional behavior may be sharp or gradual.

Elastic and Plastic Action

If the load had been removed from the specimen when the stress had attained same value S as at x, it would be found that the specimen would return to its original length. The specimen acts like a spring or a rubber band, which latter, by the way, is sometimes called an "elastic." Such action is known as elastic action. It would be found by continuing this loading and unloading that the specimen would return to its original length until stress values very near the top of the "straight" portion of the curve had been attained. Beyond such values the diagram shows that the specimen stretches "faster" than previously; deformation is no longer proportional to stress. If the specimen is unloaded after stress has been carried to values beyond the knee of the curve, it will be found that it will not return to its original length. It will have taken a permanent set or deformation. The action of the material becomes inelastic or, as is usually stated, plastic action ensues. The resulting deformation is called plastic deformation.

Frequently, the end of the straight part of the curve, as nearly as it can be determined from the diagram, is called the elastic limit. The true value of the elastic limit is the highest stress which may be applied and the specimen still return to its original length upon removal of the load. It requires a tedious test procedure to determine it. To note the distinction, the point where the curve leaves the straight line is now frequently called the proportional limit. Frequently the proportional limit is arbitrarily taken as the stress which results in a small, previously agreed upon, percentage of permanent stretch. The proportional limit is indicated on the diagram.

Shortly after this stress is exceeded the specimen, if brittle, breaks; if ductile, stretches rapidly for small increments of load increase. The material is obviously yielding to the load. It is frequently possible to note when this point is reached by watching the behavior of the testing machine or the stretch indicating device. Quite appropriately, the stress which results in the starting of such obvious yielding is called the yield point. This point is indicated on the diagram.

If stresses are carried beyond the yield point, the specimen continues to deform plastically, and it becomes longer and quite uniformly thinner until a maximum stress has been applied. This is usually called the ultimate stress or ultimate tensile strength and is indicated on the diagram. This is the value which is usually given as the strength of the material. It would be preferable to use the term maximum stress or strength because the word ultimate is so frequently used in the sense of "last" or "final."

When the maximum stress is reached (computed as described previously) the specimen starts to deform locally in a marked manner. In a tensile specimen it "necks," and since the area is being rapidly reduced, the load at which the piece breaks is less than that previously carried.

Let us now discuss the "straight" portion of the diagram a bit more. The curve shows plainly that if, theoretically, any load whatever is placed on a part, it will deform to some extent. This indicates that as a stress carrying member, i.e. for any other than decorative purposes, a material is of no value to you unless it is deformed elastically. It is "working" only when it is so deformed. In practice, of course, the deformation is kept well within the elastic range of the material and at actual low values. It sometimes happens that the design of a dynamic member must be based on permissible elastic deformation to insure proper operation and, in any case, static or otherwise, stresses must be kept low enough to insure against failure by breaking, bending, elongating, twisting, etc., and as others will later tell you, to guard against fatigue and shock failures, or increased stresses caused by corrosion and wear, or decreased strength as a result of temperature factors. As a result of these factors and others such as variations in material, overload, or increased service requirements, a designer makes his theoretical calculation for stresses and then applies a so-called factor of safety.

Basing a design on permissible elastic deformation is equivalent to saying that it is designed to have a satisfactory stiffness. This conception of stiffness is often confused with strength or force or effort required to deform a body. In an engineering sense, the relative stiffness of two materials is indicated by how much they deform when stressed to the same value; this being for both materials within their respective elastic limits. If, when both are elastically stressed to the same value, one deforms twice as much as the other it is half as stiff. When the stress is removed both will return to their original shape. The measure of stiffness, therefore, is the slope of the elastic line on the diagram, and the numerical value is obtained by taking any two points on the "straight" part of the curve, reading off the increase of stress and deformation which has occurred between these two points, and dividing one by the other. For all ordinary steels, low or high carbon, alloyed or not, heat treated or not, this value comes out at approximately the same figure, about 30,000,000. This value is called the modulus of elasticity. In other words all steels are equally stiff.

Strength Vs. Stiffness

The misconception referred to may be illustrated as follows: Imagine that you grip two small bars of identical shape and size in a vise so that they stand upright, the same length projecting above the vise jaws. Suppose one to be annealed low carbon steel having an elastic limit of 40,000 psi. and the other a heat treated alloy steel of 120,000 psi. elastic limit. One bar is obviously much stronger than the other. Now push them both horizontally at the top with the same force. They will bend out of vertical to the same distance, indicating equal stiffness, and if you remove the force they will return to the vertical position. Double the force and they will both bend double the amount and again return; triple and quadruple the force and they still respond identically.

However, one cannot go on indefinitely. Eventually the weaker bar will bend more than the stronger one, but, when the force is now removed the stronger one will return to vertical, but the weaker will retain a permanent bend or set. The weaker one has been carried beyond its elastic limit or probably its yield point. You may apply much greater forces to the stronger and it will still return to vertical but, eventually, by application of enough force, it also can be made to take a permanent set. But, note that until the yield point of the weaker was reached, it responded exactly like the stronger; it was equally stiff and so anyone would believe unless he carried his experiment beyond the capability of the weaker material. Since the stronger material requires much more effort, or force, to give it a permanent "bend" the misconception has grown that it is stiffer.

It is not possible to change the stiffness of steel by changing its analysis or heat treatment. The stiffness of a member can only be changed by changing to a different material having a different modulus of elasticity, or by altering its design; that is, the material can be placed in a more advantageous location. For instance, if an ordinary yard stick is spanned from its ends, wide side up, a 1-lb. weight placed at mid-length will cause a large deflection, but if the stick is placed narrow side up the deflection will be much less. If then a steel spring is designed and found to be too stiff, the only way to change it is to change the design. It will not be any less stiff if made of a weaker steel; or, if a heat treated job, it will not be made less stiff by "drawing" it a little higher. If these two methods are tried it will result only in a spring which will take a permanent set under a lower load.

To return to our diagram, it has been pointed out that if the stress is removed before the elastic limit is reached, the specimen will return to its original length or shape, and if carried beyond the yield point it will not return but will be permanently deformed. If, after passing the yield point to some point such as x', the load is slowly removed while data to obtain simultaneous values of stress and deformation are taken, these values when plotted will result in a set line shown as a dashed line on the diagram. The amount of set may be noted in the distance the bottom of the set line lies to the right of the origin. The set line is parallel to the elastic line and obviously the material, though stretched, is still acting elastically.

We have previously mentioned that it requires work to deform a material. The amount of this work may be obtained from a stress-deformation diagram. The ordinates measure the load in pounds on each square inch and the abscissas measure the stretch of each inch, at least up to the start of necking of the specimen. In loading the piece up to the stress level at x, the stress varied from zero to S, or the average value was $\frac{S}{2}$ psi. The stretch of each inch resulting from stressing to S is d in. as shown. Therefore an average force of $\frac{S}{2}$ lb. has moved in the direction of its application over a distance of d in. and according to the definition of work, this amounts to $\frac{1}{2}\ sd$ in-lb. Note that this represents the work done on one cubic inch of the material. The value of $\frac{1}{2}\ sd$ also represents the area of the triangle which is shaded since the area of a triangle is $\frac{1}{2}$ the base times the altitude. It follows that the area under the curve of the diagram represents the work done on each cubic inch of the material. One can take any other point, say x', and the work done on each cubic inch of the material in deforming it to this stage may be found by evaluating the area under the curve up to this point. For instance, the work would be represented by the area cross-hatched in the opposite direction.

Extent of Permanent Deformation

We have called attention to the region of plastic, or better, inelastic deformation in ductile materials. Two identical specimens of ductile steel will demonstrate the surprising extent of the permanent deformation which may occur when subjected to tension. Marked extension and "necking" occurs on the pulled specimen as compared to the one not pulled. What has happened to permit this change of shape to take place? Think about it for a moment and let me add the information that during this marked change in shape there has been no appreciable change in the volume of the piece. Marked change in shape by any of the methods used in production is accomplished with no marked change in volume. The forgeman estimates the volume of material required for a forging upon this principle, allowing for loss as a result of scaling and flash to be trimmed.

Obviously, during the pulling of this specimen there has been no separation of its structural constituents; otherwise the material would have become less dense and the piece of greater volume. No voids have been developed. In similar manner, a cylinder may be compressed to the form of a pancake and the density does not increase unless it contained voids originally. There is no evidence that "compacting" of the structural constituents of the material occurs. How may we account for these phenomena?

Possibly a crude analogy will assist. Imagine that you have a sizable fist-full of well worked putty. Suppose you squeeze down on the putty by making a tighter fist. You know that the putty oozes and slips between the fingers. You

Behavior of Metals Under Static Load

can feel it slip. However, the volume of the mass of putty before and after the squeezing is the same, though the shape of the mass has been markedly altered. In this case, compression resulted in a slip of the material upon itself. Such slipping action of one portion of a material upon another has been previously defined as a shear and it is indicated, therefore, that deformation is a result of shear.

Earlier in this discussion, it was shown that shear stresses, which, of course, tend to cause deformation by sliding action, were developed as a result of the application of tension or compression loads and that the shear stresses were present on planes at an angle to the direction of application of load. The direct, normal stresses of tension or compression are accompanied by shear stresses acting at an angle to them. When these latter become of sufficient magnitude, internal sliding or slipping will occur in a direction at an angle to the normal primary stressing and change of shape results.

Consider tensile loading as an example. As the load is applied tensile stresses are developed normal to the cross-sectional plane, say of magnitude S_t (Fig. 5). If any plane at an angle is considered, shear stresses are found to be present, say of magnitude S_s. It can be shown that the shear magnitudes are greatest on a plane at 45° to the normal and at this angle are one-half the magnitude of the tensile stresses, that is,

Fig. 5

$$S_s = \tfrac{1}{2}\ S_t.$$

If the material under tension is inherently more than one-half as strong in shear as it is in tension, then no shear slipping will occur during the loading and no change of shape will occur. By shear strength here is meant the shear stress required to start the first slipping in the original material, say the shear yield point of the original material. Upon increasing the load the tension stresses on the normal plane will reach the inherent tensile strength before the shear stresses on the 45° plane will reach the inherent shear strength and fracture by tension will occur as a straight-across break. Such breaks involve a direct separation of surfaces and are sharp and practically instantaneous. There has been no internal slipping of the material, and no change of shape, so that only the work of elastic deformation was done. Materials which break this way are called brittle.

If the material is inherently less than one-half as strong in shear as it is in tension, then as the stressing is increased the shear strength on the 45° planes will be reached before the rupture stress in tension is reached and slipping will occur, change of shape follows and energy will have to be expended in doing the work represented by the shear stresses moving through the distances represented by the respective slips. It requires time to do work and to move material, so shear actions are slow. These movements at an angle to the pull account for the lengthening noted and the final "necking." A failure involving shear is therefore more or less slow. We say the material is more or less ductile. The lower the shear strength relative to the tension strength, for values of the ratio below ½, the greater the ability of the material to deform. For reasons to be discussed later, the final fracture is usually still one of tension.

So far as tension loading is concerned, a strictly brittle material may be defined as one whose inherent shear strength is greater than one-half its inherent tensile strength, whereas in a ductile material inherent shear strength is less than one-half inherent tensile strength.

It is hoped that this point has become clear: Tension and compression stresses as such cannot cause permanent deformations and changes of shape. These phenomena can be caused only by shear stresses developed in one way or another as a result of the loading.

The mechanism of these permanent deformations caused by shear stresses may be shown schematically as follows (Fig. 6): Let us consider as before a round bar held at the bottom and twisted at the top and note the behavior of a longitudinal stack of small imaginary cubes with one face at the surface. The sketches show only the surface faces of these cubes. At the left, they are shown before the bar is loaded. Let us consider that at the planes between cubes the material is actually somewhat less strong against shear than elsewhere. Now let us apply sufficient load to deform the bar elastically through an angle $\delta_1{}^\circ$. Let us imagine further that this load has brought the shear stress to the point where the weaker planes are just on the verge of slipping —that is, as far as these planes are concerned the material may be considered to be at the elastic limit. Let us call this load the elastic limit load, as indicated, and the angle $\delta_1{}^\circ$ the elastic limit angle. At this stage the bar as a whole has twisted and each cube has skewed through the angle $\delta_1{}^\circ$. Now, if the bar is additionally loaded, the planes between cubes will start to slip and each skewed cube will "step" over slightly. The stack has now assumed the angle $\delta_1{}^\circ + \delta_2{}^\circ$, but each cube has not been carried beyond its elastic limit. If the bar is now unloaded, each cube will recover and right itself, but the "steps" which resulted from slip will remain and the bar as a whole will have a permanent set represented by the remaining angle $\delta_2{}^\circ$.

Now suppose we were able to pin each of these cubes together by means of small dowel pins vertical to the weak planes and by this means strengthen the planes against shear. We could then deform the bar further elastically before slipping occurred and by using more or stronger dowel pins we could reach a condition where the material would slip in other planes. Note that a greater load would be required to cause slipping. If these were dowelled, or keyed in turn, it is readily conceivable that the material as a whole could be so strengthened against shear slipping that this no longer occurs. It would then, when loaded sufficiently, break by other stresses, such as tension, and the break would be sharp, as already explained, and it would be stated that the material had been made brittle.

It would also be stated that it had been hardened, for hardness is usually defined as the measure of the resistance of a material to deformation. The most universally satisfactory theory of hardening and strengthening of materials by heat treatment or otherwise is based upon this fundamental conception and is known as the slip interference theory of hardening.

It has been indicated that regardless of the loading of a member there are planes along which shear stresses occur and tend to cause slipping, deformation and change of shape. The engineer must design to avoid rupture by either tension or shear or excessive deformation which results from shear. It is necessary therefore to keep an eye on the maximum tension and shear stresses developed and their direction of action. Their magnitude must be kept well within the capabilities of the material being used.

Relation of Crystal Structure

Now, let us consider the structures of the metals and discuss the relation of this factor to their behavior under load. You know that all metals are aggregates of crystalline grains. This means that the atoms or molecules making up each grain are arranged in a definite geometric pattern. A single crystal has one or more planes of easy slip. Such crystals, if loaded, may fracture by shearing on planes of easy slip or by pulling apart by tension in a direction perpendicular or normal to these planes.

Now, if we assume we have a single crystal test bar of a pure metal having a single easy slip direction or orientation, it would appear that at a rather low stress, slip would start on some one of the slip planes and continue on that plane. In this case the failure would come at rather low loads and elongations. According to the schematic representation of the mechanism of permanent deformation just discussed, there would be one long "step" in the bar and rupture would follow.

Actually this does not happen. There are a great number of parallel planes of easy slip in such a crystal and the slip starts on one, proceeds to a slight extent and then stops, whereupon as the load is increased slips start and stop on other planes until many have taken part and thereafter the performance is repeated. The sum of all these slight slips and repetitions of slip add up to the noticeable permanent deformations which may be readily measured.

It is difficult to account for this behavior. Obviously, however, something increases the resistance to slip on a plane after slip has progressed slightly. We may be permitted to stretch our imagination and "surmise" a reason. The planes are possibly not perfect (we can always imagine, at least, a roughness of atomic proportions). The stressing up to the point of first slip has resulted in elastic deformation which is an effect of warped space lattice and possibly indicates a warp or wave in the slip plane. Movement of warped planes along one another increases the resistance to movement. It is possible that when high spot encounters high spot, material is torn loose and acts as keys.

There is also a theory that in the melt, before freezing, groups or blocks of atoms arrange themselves in definite and perfect geometric arrangement and upon crystallizing, these "blocks" arrange themselves in definite order to form the larger crystal. It is conceived that these "blocks" do not arrange themselves quite perfectly, so that the crystal large enough to be identified and studied is still thought of as not having perfect geometric arrangement throughout.

At any rate, regardless of the reason, it has been amply demonstrated and experience indicates that resistance to slip increases as a result of slip and this is equivalent to saying that slip causes hardening and strengthening.

Now, if we consider a solid solution, we have a second atom arranged in the space lattice of the solvent material, either replacing atoms or "wedging" between them and it is known that this causes lattice distortion and hence, it would seem, a more uneven slip plane.

Further, commercial metals are aggregates of grains and each has its own orientation. The grains are arranged promiscuously in every possible direction. This, in itself, develops a greatly increased resistance to deformation of such a material as a whole. For instance, in tension, certain grains will have their easy slip planes, at an angle of about 45° to the load and as noted, maximum shear stresses are developed at 45°. As soon as slip starts in this grain, however, it brings pressure to bear on neighboring grains which are stronger in this direction because their orientation is different and they assist in resisting the slip in the original grain. Note that the tendency of the shear stresses in tension loading would be to start shears at 45° and as slips develop, a lengthening and thinning would occur. It also accounts for the contour of the "neck" at the zone of great localized deformation being at an angle of approximately 45°.

The second element added in alloying a metal frequently forms a distinct compound instead of forming a solid solution. Such compounds are frequently hard and strong. They act as keys to bolster the shear strength of the matrix material, thus hardening and strengthening the matrix.

Behavior of Brittle Material

Let us now briefly discuss a few examples. Ordinary gray cast iron is classed as a brittle material and structurally is very complex, containing free ferrite with silicon in solution, iron carbide (in pearlite), iron phosphides, iron sulphides, pearlite, and graphite in the form of knots, plates, and whorls.

When cast iron is subjected to tension load, the graphite deposits, being of no appreciable strength, break almost immediately. The load is carried by the remaining sound material. Since graphite occupies an appreciable percentage of the cross-sectional area, the actual stresses on the remaining sound material are considerably higher than computed by dividing load by sectional area. We do not, and probably cannot measure the actual stress intensity in the sound material. Further, we now know that the ferrite grains will show various "stiffness factors" depending upon their orientation, and it is reasonable to believe that the harder constituents will show a higher stiffness factor than ferrite in any case. As load is further increased we get first a slight elongation of the material as a whole. A glance at a stress-deformation curve will indicate that at equal deformations the "stiffer" constituents will be stressed to higher values. So we find that the stress varies widely from grain to grain and constituent to constituent. Our values of computed stress are only average values and we do not find the real stress intensity in any grain or constituent. Very soon, upon further application of load, the weaker ferrite grains start to deform by slip; this occurring first in grains unfavorably located to resist the stress. Such readjustment tends more nearly to equalize the stresses from grain to grain and constituent to constituent.

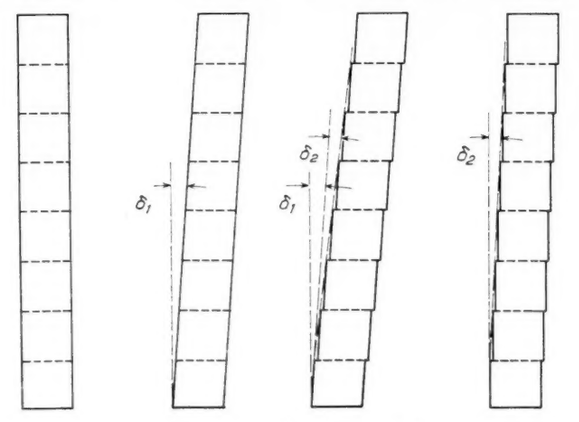


Fig. 6

Behavior of Metals Under Static Load

Gradually more and more of the free ferrite grains, then pearlite grains, etc., take part in the slipping deformation. On the whole, however, cast iron shows only slight deformations before break occurs. Weak brittle graphite is interspersed throughout and the end of each whorl acts as a notch and stress concentrator. There are sufficient hard, brittle constituents present such as carbides, phosphides, and iron sulphides, to act as keys to interfere with shear slipping. As a result of these combined actions the breaking stress of the stronger and more brittle constituents is soon reached and break follows after little elongation and at comparatively low stressing in a straight-across sharp break.

Considering the action described above, it becomes clear why the stress-deformation curve of cast iron should show a "straight" or elastic part of the curve which is comparatively short and probably, theoretically, non-existent. The fact that graphite occupies such a large volume also accounts in large measure for the comparatively low value of the elastic modulus as determined.

It is of sufficient interest to call attention to another point here. It will be equally applicable to any metal.

Suppose we load the material until some of the weaker and unfavorably oriented grains have definitely elongated by shear slipping and many others are still acting elastically, i.e., some permanent measurable set has taken place. Now suppose the piece is unloaded gradually. As was pointed out sometime ago, the piece will recover along an elastic line. Each constituent and grain starts to recover along its respective elastic line, but what must happen, as the stress is gradually reduced, to the grains which have been elongated by slip?

It seems obvious that they will reach a condition of zero stress while still longer than originally, and while grains which have not elongated permanently are still in tension. As the load is further reduced, the grains which have elongated only elastically will continue to recover and by so doing will place plastically elongated grains in compression and in some measure reverse the direction of their previous slips.

When the piece as a whole is unloaded and is usually considered unstressed, it is plain that internally it may still be severely stressed from grain to grain. A permanent set remains and grains which were elongated by slip are still somewhat elongated and are under compression; grains which were not elongated by slip are still elongated elastically and are in tension. Such unloading of a piece which has been permanently elongated does not remove the internal stressing and cannot do so. This can only be relieved by a heat treatment for stress removal.

Tension Loading of Ductile Material

Let us consider next the tension loading of a ductile material, say steel containing ferrite with islands of pearlite. The basic material here is ferrite of rather low strength and yield values and excellent ductility, and carbide which is hard, strong and brittle.

The crystalline grains are again oriented in every conceivable direction. As load is applied all grains elongate elastically and data taken from the bar as a whole would plot as the "straight line" part of the stress-deformation diagram as previously indicated. Certain grains throughout the matrix are unfavorably located to resist the shear stresses which are maximum at 45°. It has been indicated that if so oriented they start to slip at a comparatively low stress and have a lower modulus of elasticity. Throughout the matrix, therefore, grains here and there start to slip and elongate, and immediately start to work harden and strengthen.

Grains which have a slightly more favorable orientation are then brought to the slipping stage with increased load, and so on; and slip repeats in grains which have previously deformed. Undoubtedly deformation of many isolated grains has occurred before the over-all effect is sufficient to be measurable. But a load is reached where, with very little increase of load, marked elongations occur; this marks the yield point.

With very soft, low carbon steels the yield point occurs with remarkable abruptness. The carbide-containing areas are small and widely distributed and inefficient as keys to bolster the matrix as a whole. The stress required to involve only a few grains in the slipping action needs to be increased only slightly, it appears, to increase tremendously the number involved.

As the load is further increased, work hardening develops throughout the material, and it requires constantly increasing loads to continue the deformation. During this stage, general and uniform contraction of the piece takes place. Eventually, however, when the maximum load is reached, the piece starts to "neck" at a localized spot and shortly thereafter breaks at this place.

It is clear again that after the elastic limit is passed some grains have slipped and elongated while others are acting elastically and, later in the loading, individual grains have not elongated plastically to the same extent. As pointed out in the discussion of cast iron, upon unloading the piece, it will not be relieved of internal stress. Some grains will be in tension and will be subjecting other grains to compression.

Torsion Loading

Now let us consider the action of a brittle material like cast iron under torsion loading, that is, when subjected to twisting action. The primary stresses developed by this loading are shears, as indicated in Fig. 7.

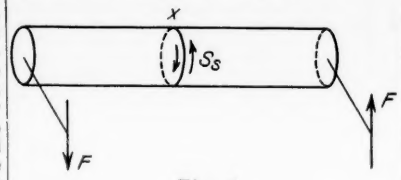


Fig. 7

Instead of the two forces, F, shown acting through lever arms, you may imagine the left end held rigidly and the right end twisted. If you cut the bar on any imaginary plane as indicated at X, the end at the right would tend to slip past the left end. Internal stresses are resisting this tendency. These stresses and their direction of action are indicated by the arrows. It can be demonstrated that the deformations and stresses vary from zero at the center to maximum at the surface. It is evident, therefore, that rupture would start at the surface and work inward. It can also be shown that at any point in the bar where shear stresses are acting as indicated, there are present tension and compression stresses of equal magnitude acting at 45° to the shear stresses. That is, $S_s - S_t$ at 45° $= S_c$ at 45°.

As far as torsion loading in concerned, if a material is inherently stronger in shear than in tension, it will fail by tension sharply at an angle of 45° to its length. If a material is inherently stronger in tension than in shear, it will ordinarily fail by shear straight across. In the first case we say the material is brittle and in the second, ductile.

Now, as the cast iron bar is loaded, we get first an elastic deformation showing up as a twist of small amount and eventually a very minor permanent set. The internal action is entirely analogous to that discussed under the tension test. It must only be remembered that the shear stresses are acting directly across the piece. Eventually slight permanent twist or set is noted, followed shortly by a sharp break. The fracture, since cast iron is brittle, takes the form of a long helix at 45° to the length, for the break is caused by tension.

A ductile material subjected to torsion will take a certain twist elastically and if unloaded will return like a spring. Eventually, by internal slipping action, as discussed, permanent twist develops. The first grains to be affected are those of the weaker constituents which happen to be unfavorably oriented and at the surface where stresses are highest. The slipping action gradually spreads to other grains at the surface and then to those lying deeper. The twist is gradual and occasionally remarkable in extent. The slipping is caused by the action of shear stresses which are directed directly across the section. There is no tendency to elongate the pieces or to reduce the diameter. The piece continues to "wind up," work hardening and requiring greater load to continue the twist until at some localized plane rupture of surface crystals by shear occurs and the crack so formed travels inward until rupture is completed, straight across. The break is slow because it is by shear and because it is progressive from the surface to the center.

To demonstrate these torsion types of failures an experiment may be performed using a stick of ordinary school chalk (representative of brittle material) and a small lead test piece (representative of a ductile material).

When a piece of chalk is twisted, very little force or work is required to break it and the fracture is in the form of a helix at an angle about 45° to the length. Upon twisting the lead test piece, little force is required to start the twisting, but as twisting progresses more and more force is required until it becomes very difficult to grip the piece sufficiently. No noticeable change in length or diameter develops. After some 12 or 14 turns, the effort required to continue twisting decreases rapidly and the piece ruptures after about 16 turns, straight across.

Transverse Loading

One more type of loading should be discussed, namely transverse.

Transverse loading tends to bend a member. A beam supported at the ends and loaded between supports is a common example. Suppose you have a flat bar and the means of grasping it by the ends and bending it into a complete circle in such a way as to bring the two ends together flush.

If this were done, and you measured the circumference of the circle formed by the center of the bar, you would find it the same length as the original bar. The circle formed by the convex surface of the bar is obviously one of larger radius and therefore greater circumference; that formed by the concave inner surface of smaller radius and therefore lesser circumference. These lengths were all the same in the original straight bar. It becomes plain that the metal towards the convex side has been stretched and that towards the concave side shortened.

It may be shown that this lengthening and shortening is directly proportional to the distance from the center or neutral axis of the bar. Now you know that lengthening is an indication that tension stressing is involved, and shortening that compression stressing is involved. It may be shown that the bar has been stressed in tension on one side and in compression on the other and that the stresses increase from zero at the neutral axis to maximum at the surfaces. The example is an exaggerated case of bending and illustrates that transverse loading subjects the side tending to become convex to tension and the side tending to become concave to compression. As in the direct application of tension and compression loads, there are developed secondary shears acting at 45° to the length of the member.

In view of the discussions given previously it seems hardly worthwhile to say much more. A brittle material will bend elastically when loaded transversely and will break sharply straight across in tension, the break starting at the surface on the convex side. A ductile material will bend elastically until the yield point is reached. Upon additional loading, it will permanently lengthen and become narrower on the convex side, and shorten and widen on the concave side and eventually it will, due to the action of the shears, also thicken on the concave side and then buckle or fold up. It is hoped that the discussion of tension and shear stressing in tension loading and compression and shear stressing in compression loading, together with the discussion of the slip mechanism, will assist in understanding this behavior.

In closing it might be mentioned that designing engineers take account very satisfactorily of such factors as have been discussed, and failures as a result of static loads are very rare. It is more difficult to account for factors which will be taken up by others in following discussions, such as wear, corrosion, impact, fatigue and the effect of temperatures.

It is still the designer's and metallurgist's dream to overcome all these difficulties and be able to evolve structures economically which would theoretically last forever. No such results have been reported, though examples of success to the extent that structures and machines, given reasonable care and attention, last until they become obsolete are not uncommon. Broadly considered if deterioration and final failure must occur, and though the practice would be a dangerous one, the next ideal in design is to evolve structures economically in which, after a satisfactory useful life, every member would fail at the same time.

Your Membership Button!

This attractive rolled gold and black enamel button is now available to members. Symbolic of the profession and indicative of good standing in the Society, it is a badge to be proud of.

Tear out this form, mail it in with $1.00, and get your button.

Name_____

Address_____

AMERICAN SOCIETY FOR METALS

7016 Euclid Avenue, Cleveland, Ohio

HERE AND THERE WITH A.S.M. MEMBERS

OVER a period of approximately 18 years, one of the strongest supporters and most active members in the work of the Society has been W. S. "BILL" BIDLE, president of the W. S. Bidle Co. of Cleveland.

Bill took an active part in the formation of the Cleveland Chapter on Jan. 24, 1919, and served as its first chairman. Mr. Bidle was one of the delegates from the Cleveland Chapter to the first convention held in Chicago in 1919.

The next year when the amalgamation of the two heat treating societies took place to form the American Society for Steel Treating (now the A.S.M.), Mr. Bidle was designated as treasurer and served in that capacity for two years. It was during these early and strenuous days in the life of the Society that Bill's exceptional ability in financial matters stood the Society so well, as evidenced by its splendid condition at the present time.

Mr. Bidle then served as vice-president for one year, and in 1925 as president. Ever since that time he has served as a member of the important Finance Committee of the A.S.M.

When Bill's resignation was received at the last meeting of the Board of Trustees, it was accepted with reluctance and sincere regret. An expression of appreciation for his long and continuous services was voted.

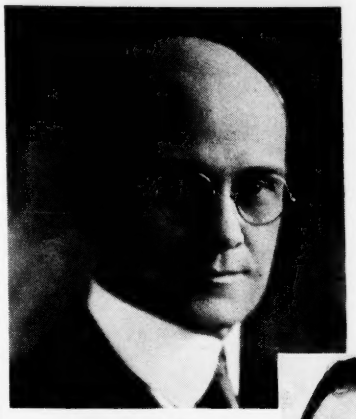
* * *

THREE A.S.M. members were awarded gold medals at the annual convention of the American Foundrymen's Association in Milwaukee, May 6.

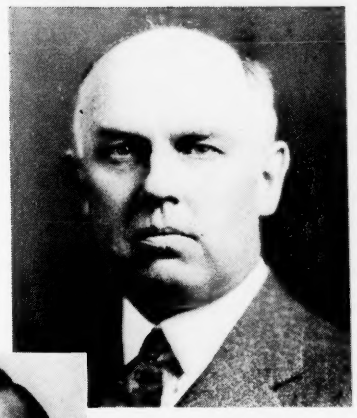
The John A. Penton medal has been awarded to JOHN WARD BOLTON, Lunkenheimer Co., Cincinnati, in recognition of his work in metallurgy and the practical application of research to the advancement of the foundry industry.

The William H. McFadden medal has been awarded to CHARLES WILLIS BRIGGS, U. S. Naval Research Laboratories, Anacostia, Washington, D.C., for his direction of important research and published writings on metallurgy, of great value to steel castings producers.

The J. H. Whiting medal has been presented to DR. JAMES TUCKER MACKENZIE, American Cast Iron Pipe Co., Birmingham, in recognition of his research and practical work in the advancement of gray iron foundry practice.



W. S. Bidle



R. S. Williams

J. W. Bolton

C. W. Briggs

J. T. MacKenzie

"Bill" Bidle Resigns From A.S.M. Finance Committee ... Williams appointed department head ... Bolton, Briggs and MacKenzie win A.F.A. medals.

MASSACHUSETTS Institute of Technology has announced the division of its Department of Mining and Metallurgy into two distinct fields of professional education.

The new Department of Metallurgy will be directed by DR. ROBERT S. WILLIAMS, for many years professor of physical metallurgy, and member of the Boston Chapter, A.S.M., for 14 years.

The Department of Mining Engineering will be administered as a separate department under the direction of Professor W. Spencer Hutchinson, who has long been head of the courses in mining and metallurgy.

In announcing this change, Dr. Karl T. Compton, president of Technology, said that advances in mining engineering and the significant progress in metallurgy make it desirable to recognize them as separate professional fields, each of great importance and promising in opportunities.

The new Department of Metallurgy will give special attention to physical and process metallurgy, as well as metallurgical production, the latter being concerned primarily with the economical and statistical functions of the industry.

Dr. George B. Waterhouse, president-elect of the A.S.M. will have charge of courses dealing with the economies of process metallurgy as he has had in the past.

HOSPITALIZED in Middletown, Ohio, is STUART OLIVER, chief metallurgist, Delco Products Corp., Dayton, and past chairman of the Dayton Chapter.

Mr. Oliver suffered a fractured skull in an automobile accident which occurred a few weeks ago while driving down to the Middletown Airport.

* * *

ALBERT J. DORNBLATT, REVIEW reporter for the Washington Chapter, has resigned as head of the Metallurgy and Chemistry Section of the Naval Academy Postgraduate School at Annapolis, after eight years on the faculty there. He has accepted a research associateship at the National Bureau of Standards, Washington, in the employ of The American Metal Co., Ltd., N. Y.

* * *

THE Acheson medal of the Electrochemical Society has been awarded to FREDERICK M. BECKET, president of the Union Carbide & Carbon Research Laboratories, Inc., N. Y., for outstanding contributions to electrometallurgy.

* * *

J. M. WATSON, past president of the A.S.M., has resigned as development engineer for Jones & Laughlin Steel Corp., Detroit District.

DEATHS

FREDERICK C. LANGENBERG, vice-president, U. S. Pipe & Foundry Co., Burlington, N. J.; Howe Medalist, 1926; member of Handbook Committee, 1926 to 1929.

✝ ✝ ✝

A. J. WILSON, metallurgist, Republic Steel Corp., Massillon, Ohio, member of Canton-Massillon Chapter since 1919.

✝ ✝ ✝

ON APRIL 25 the Philadelphia Chapter and the American Society for Metals lost a most loyal and beloved member, JOSEPH E. CHAPIN, chief chemist of the Philadelphia Navy Yard. A regular attendant at meetings, Joe was affectionately known by every member of the Chapter.

J. E. Chapin

It was in 1920, during the first full year of the Chapter's existence, that the name of Joseph E. Chapin was first entered on the rolls. Since then he has held office during practically every year, and has performed the duties of every office conscientiously.

During recent years he has represented the Philadelphia Chapter in the Council of the Affiliated Technical Societies of Philadelphia. He was chairman of the Council for a number of years. Perhaps no more fitting tribute can be paid him than that the Philadelphia Chapter was requested this year to be sure to reappoint Mr. Chapin as its representative to this body.

Mr. Chapin spent his boyhood in the vicinity of Auburn, N. Y. He entered the Government service at the Navy Yard, New York, in a clerical capacity, and meanwhile attended Cooper Union, from which he was graduated with a Bachelor's degree in chemistry.

Mr. Chapin spent the whole of his professional life (some 35 years) in the Government service. He started his career as a chemist at the laboratory of the Navy Yard in New York, and was selected in 1915 to take charge of the chemical laboratory at the Philadelphia Navy Yard. When the consolidation of laboratories took place, he was put in charge of the greatly enlarged chemical section, and at the time of his death supervised the work of 25 chemists.

Intermediate Alloy Steels Form Subject Of Cincinnati Meeting

By George H. Gerdes

Cincinnati Chapter—The so-called intermediate alloy steels used in the rolled or normalized condition in flat stock and tubular goods were discussed by H. J. French, International Nickel Co., in a talk on "Some Recent Progress Relating to Alloy Steels," on March 11.

Particular attention was given to the steels containing copper and nickel, either with or without additional alloying elements.

A graph was shown illustrating the strength of welded I-beams of one of the intermediate alloy steels, which showed an advantage of 25 to 50% in load carrying ability, as compared to the plain low carbon steels.

Discussion of the copper alloy steels revealed that while copper strengthens the steel when added in proportions above 0.50%, a surface rotting in rolling is encountered which is cured by additions of nickel.

Graphs were shown which portrayed improvements in fatigue ratios and fatigue limits when the usual 0.50% carbon steels were replaced by steels having about one-half as much carbon and the ferrite strengthened by additions of nickel.

The adverse effects of press fits on the fatigue properties of shafts can be alleviated by the use of pads, which are only moderately effective, by the machining of stress relieving grooves in the faces of the press fitted members, or by the cold rolling of the surface of the shaft before press fitting.

An error which is often made in attempting to weld alloy steels is using too high a carbon content. Carbon, according to the speaker, should preferably be kept under 0.25% and even 0.15%.

Si-Lux Acquires New Plant

The Si-Lux Co. of Pittsburgh has acquired ownership of the J. H. R. Products Co., Willoughby, Ohio, manufacturers of industrial chemicals since 1916 and one of the country's most important producers of barium.

The Si-Lux Co. is headed by Albert Pavlik, who assumes the presidency of the Ohio corporation. The name of the J. H. R. Products Co. will be changed to Si-Lux Corp., and the plant will be modernized and enlarged.

M. J. Rentschler, who has been manager of the J. H. R. Products Co. since its organization, will continue in a similar capacity.

Brass and Bronze Alloys Developed by Reference To Equilibrium Diagrams

By Adolph O. Schaefer

Philadelphia Chapter was treated to a most interesting consideration of "Brasses and Bronzes" by C. H. Davis, metallurgist, American Brass Co., at a regular meeting on March 26.

For the one meeting on the 1936-1937 program devoted to non-ferrous metallurgy, a large crowd was on hand. The discussion following the talk lasted well on to midnight, and was ended only by the chairman's firmness.

Mr. Davis discussed the manufacture of brass, and showed some excellent slides. The compositions and properties of all of the various alloys used for modern applications of brasses and bronzes were developed from the equilibrium diagrams of the metals. The equilibrium structures were also shown in a series of photomicrographs.

The dinner preceding the meeting was addressed by Joseph G. Jackson, Patent Attorney, and a member of the Chapter. Joe, as he is known to the members, presented a series of slides combining the odd and the fantastic, as well as some patents which have made history.

Free Literature — Mail Coupon Below

Melting Costs
Comparative melting costs using various types of crucible open-flame, electric, oil and gas fired furnaces were computed by R. H. Stone in *Metal Industry* in 1933 and are reprinted by Campbell-Hausfeld Co. Bulletin Mya-117.

Brazing
The process and principle of electric furnace brazing are detailed in a folder by the Metal Electric Processing Co., a firm which specializes in heat treating in controlled atmosphere electric furnaces. Bulletin R-167.

Flat Spring Design
A bulletin of helpful technical data and information for manufacturers on how to design flat springs to meet definite requirements has been prepared by the research department of the Beryllium Corp. of Pennsylvania. Bulletin R-166.

Hy-Speed Case
A striking and interesting new booklet on Hy-Speed Case has just been published by the A. F. Holden Co. Typical applications and results are cited. Bulletin Fa-55.

Drawing Furnace
A new convected air gas fired furnace for drawing and tempering dense loads has been announced by Despatch Oven Co. Complete details concerning its design and operation, the results obtainable, and prices are given in Bulletin Dy-123.

Refractory Blocks
Light-weight, low heat storage insulating refractory blocks known as "Insulblox" for reducing heat storage and radiation losses at operating temperatures up to 2200° F. are described in a folder by Quigley Co. Bulletin Ea-139.

Dust Collector
How the Schneible multi-wash dust and fume collector operates and what it does are clearly shown in a catalog giving details on existing installations. Published by Claude B. Schneible Co. Bulletin Ca-161.

Inert Gas
The rapid development in the use of inert gases in industry during recent years makes a folder of Roots-Connersville Blower Corp. particularly timely. It describes the Harrison inert gas producer — a fairly new but well-proven piece of equipment. Bulletin Ca-131.

Tool Room Furnace
A new type of lining and one-valve control are two of the features of the American Gas Furnace Co.'s new tool room oven furnace that would make it economical to replace many older furnaces now in operation. Fully described in Bulletin Ox-11.

Tocco Process
This amazing new and extremely accurate method of heat treating is described in a new four-page leaflet, yours for the asking. Distributed by Ohio Crankshaft Co. Bulletin Oy-145.

Centrifugal Casting
A new circular has been prepared by the Calorizing Co. describing their methods of centrifugal casting. Bulletin Dy-26.

Modern Metallograph
The new Bausch & Lomb research metallographic equipment, which is arousing so much interest and favorable comment in the profession, is the subject of advance literature, recently issued. Bulletin Ba-35.

Cutting Oils
The problems of machine tool lubrication engendered by the high speed production and close tolerances of modern industrial operations are discussed and progress in cutting oils during the past few years reviewed in a booklet by D. A. Stuart & Co. Bulletin Jy-118.

Rustproofing
How the Detrex method of solvent degreasing provides the advantages of speed, economy, and satisfactory cleaning before all kinds of rustproofing and finishing operations is pointed out in a leaflet by Detroit Rex Products Co. Bulletin Dy-111.

Spoilage Insurance
C. I. Hayes, Inc. has compiled a record of reports from over 300 users of their "Certain Curtain" controlled atmosphere furnaces showing how these furnaces have cut down spoilage in the heat treatment of tools. Bulletin Sx-15.

Limitrol
An automatic shut-off instrument designed for use with or without controllers of any type to protect furnaces and furnace loads from excessive heating due to a weakness in control or failure in switching apparatus is described by Wheelco Instruments Co. Bulletin Ea-110.

Steel Service
"Steel Service" is the title of a bulletin which gives valuable information on testing methods and pickling control charts. It is distributed by the Grasselli Chemical Dept. of E. I. du Pont de Nemours & Co. Bulletin Aa-29.

Cold Finished Bars
The importance of quality in cold finished steel bars is stressed in a small booklet by Union Drawn Steel Co., which describes the various types of carbon and alloy steels available in this form. Bulletin Ca-83.

Hard Facing
An interesting and well-illustrated story is Lincoln Electric Co.'s 14-page booklet on hard facing for wear resistance. It also contains complete information on all types of Lincoln hard facing electrodes and gives the conditions for which each type is suited. Bulletin Ay-10.

Metal Heating
Improvements in furnace economies, operating conditions and appearance, furnaces that will more satisfactorily meet old requirements or handle new processes, service that will help solve the most stubborn problems are offered by Mahr Mfg. Co. in Bulletin Ea-5.

Alloy No. 10
A high temperature muffle furnace, the first of the Hevi Duty line of laboratory furnaces equipped with Alloy No. 10 allowing working temperatures to 2400° F. Bulletin Jb-44.

Flux
A short, informative bulletin covering the low melting temperature, rapid solvent action and wide temperature range of Handy Flux — which speeds up and improves brazing operations. Handy & Harman. Bulletin Oy-126.

Furnace Control
How the Lindberg Control functions in balancing the rate of heating of a furnace or oven with the varying heat requirements is told in an attractive new bulletin issued by Lindberg Engineering Co. Bulletin Nv-66.

Photo-Electric Balance
C. J. Tagliabue Mfg. Co. has christened its newest, simplest and fastest recording potentiometer the "Celectray" from the photocell, electric current and light ray by means of which it operates. Described in Bulletin Ea-62.

Air Weight Control
An illustrated booklet of sure-fire interest to the foundry trade has been issued by the Foxboro Co., explaining in detail the advantages of the "air-weight controller" used in America's leading foundries. Bulletin Ea-21.

Oxidation
Designers confronted with oxidation problems connected with cracking coils, polymerization plants, superheaters, high pressure steam plants, air heating equipment and recuperators will welcome a folder by Timken Roller Bearing Co. containing data on oxidation at 1000, 1250 and 1500° F. Bulletin Ea-71.

Calculator
A handy gadget is a sliding weight calculator which can compute weights per lineal inch of steel for 161,200 cross-sections. Pocket-size, it contains tables for rounds, hexagons, octagons, squares and flats. Distributed by Heppenstall Co. Bulletin Ea-122.

Brazing
Some of the jobs G-E electric furnace brazing is doing for manufacturers in the metal working industry, and the benefits obtained by its use are described in a reprint of a technical article by H. M. Webber, application engineer, General Electric Co. Bulletin Ea-60.

Sheet Metal
One of the most modern of the current pieces of industrial literature dealing with sheet metal is Republic Steel Corp.'s "The Path to Sheet Metal Permanence," a 20-page illustrated booklet. Bulletin Ea-8.

Pneumatic Control
The free-vane principle of pneumatic control is recognized as a simple, reliable means requiring practically no power from the measuring unit to operate the control apparatus. A bulletin by Bristol Co. is devoted to Ampliset free-vane controllers. Bulletin Ea-87.

Daily Reminder
Titanium Alloy Mfg. Co. publishes a small monthly memorandum book containing a thought-provoking quotation on the page for each day and supplemented by several pages of technical information on titanium. Bulletin Ea-90.

Rails
"Brunorizing" is a new method of producing an improved steel rail for today's heavier and faster trains. A nicely printed and well-illustrated 24-page booklet by United States Steel Corp. explains the process. Bulletin Ea-79.

Diamond Wheels
A striking presentation is made by the Carborundum Co. in a 52-page booklet on diamond wheels. Detailed technical information is contained and a price list attached. Bulletin Ca-57.

Sheet Containers
The mechanical and thermal requirements peculiar to sheet carburizing boxes are explained in an illustrated folder by Driver-Harris Co. describing this particular type of equipment in detail. Bulletin Ea-19.

Graphitic Corrosion
The peculiar form of disintegration occurring in cast iron which is known as graphitic corrosion is explained in a reprint of a technical article by Wesley, Copson and LaQue of International Nickel Co. Bulletin Ea-45.

Forging Steel
A folder on J & L "correct balance" forging steel shows how consistent profits can be obtained in the forge shop with better quality parts and greater customer satisfaction. Jones & Laughlin Steel Corp. Bulletin Ea-50.

Pyrometers
What pyrometers can do for you is shown in an excellently printed book, illustrated in color, covering the complete line of pyrometers of the millivoltmeter type made by Brown Instrument Co. Bulletin Ea-3.

Testing Machines
An extremely handsome, spiral-bound, segregated catalog tells all about the various hydraulic and screw power testing machines made by Tinius Olsen Testing Machine Co. Bulletin Oy-147.

Galvanizing
An informative, historical, simple digest of galvanizing forms a guide to longer life for iron and steel products. This handsome, handy, 24-page book beautifully printed in color is distributed by American Hot Dip Galvanizers Association, Inc. Bulletin Ea-167.

Air Heaters
Diagrams, illustrations and detailed text in a folder by General Combustion Corp. give a very clear conception of the construction and applications of General air heaters. Bulletin Ea-166.

Salt Bath
"Heating from the inside out" is what makes the Ajax-Hultgren salt bath furnace practical. Ajax Electric Co. explains this new operating principle in an interesting folder. Bulletin Oy-43.

Copper Bulletin
A new clearing house for news of developments in brass, bronze and copper, the "Copper Alloy Bulletin," issued by the Bridgeport Brass Co., made its appearance with the March issue. It is edited for the technical and engineering audience. Bulletin Da-163.

Riveting Aluminum
The riveting of aluminum and its alloys is treated from all angles in a comprehensive little booklet by the Aluminum Co. of America. Materials, types, riveting practice for various applications, and properties of the riveted joint are covered. Bulletin Da-54.

Pot Furnaces
Pot furnaces for hardening, tempering and forging are described by Surface Combustion Corp. by means of illustrations and complete data concerning an existing installation. The folder also tells about Surface Combustion air heaters. Bulletin Da-51.

Toolmakers' Microscope
Only recently have optical methods of measuring and testing been introduced in the workshop. These methods — particularly adapted to measuring small and intricate parts — and the equipment used are fully described in a booklet by E. Leitz, Inc. Bulletin Da-47.

Insulation Service
"Barriers to industrial waste" is what Johns-Manville calls insulating materials. A small 64-page booklet catalogs their complete line, which contains a product for every temperature. Bulletin Da-100.

Welding Pipe Lines
An improved welding method used in the construction of over 5000 miles of cross-country pipe lines is discussed in a 32-page illustrated booklet published by The Linde Air Products Co. Bulletin Da-63.

Turbo-Compressors
Spencer Turbine Co. has turbo-compressors in all sizes and types for oil and gas-fired furnaces, ovens and foundry cupolas. Special types for special purposes such as gas-tight and corrosion resisting applications are also described in Bulletin Da-70.

Spectrum Analysis
The elements of both qualitative and quantitative spectrum analysis are contained in a handy booklet by Carl Zeiss, Inc. A price list covering all equipment is included. Bulletin Da-28.

Meehanite
A compact but complete specification chart gives the recommended grades of Meehanite metal for various service requirements. Complete physical properties and applications are included. Bulletin Da-165.

Tool Steel Selector
A wall chart, 30 x 20 in., to be used as a means of selecting the proper type of tool steel is offered by Carpenter Steel Co. to tool steel users in the U.S.A. only. Bulletin Jz-12.

Optical Pyro
No correction charts, accessories, nor upkeep are required with the Pyro optical pyrometer, which is a totally self-contained direct-reading precision instrument made by Pyrometer Instrument Co., and described in Bulletin Ay-37.

Hydraulic Tester
Of interest to all engineers recommending or purchasing universal testing machines is a book by Riehle Division of American Machine and Metals, Inc., on the development of the precision hydraulic testing machine. Bulletin Ba-157.

New Joining Process
Metal parts are joined cheaply, neatly and strongly by Electric Furnace Co.'s new, inexpensive non-oxidizing furnace atmosphere and their new, continuous brazing, coppering and soldering furnaces. Full details are given in Bulletin Ar-30.

Alloy Castings
Michiana Products Corp. has published a new book describing Michiana corrosion resistant and stainless steel alloys. Generously illustrated, it suggests many savings for the use of these alloys. Bulletin Oy-81.

Molybdenum
Climax Molybdenum Co. presents their annual book giving new developments in molybdenum, particularly as an alloy with iron and steel. The engineering data presented are made clear by many tables and illustrations. Bulletin Dc-4.

Stainless Data Book
All users of stainless and heat resisting alloys should find invaluable the information contained in a booklet published by Maurath, Inc. giving complete analyses of the alloys produced by the different manufacturers, along with the proper electrodes for welding each of them. Bulletin Jy-125.

Liquitol
The use of Liquitol for controlled cooling of iron and steel castings and ingots is fully described in a bulletin by Alpha-Lux Co., Inc. Bulletin Ma-120.

Stress-Strain Recorder
The many applications of the Baldwin-Southwark stress-strain recorder, its unique advantages, and the many ways it can give unusual service will be extremely interesting to all who have to do with testing methods and equipment. Bulletin Ba-67.

Nickel Silver
Riverside Metal Co. has just published a beautiful booklet on nickel silver. If you want the latest information on this subject, presented in an attractive, interesting manner, write for Bulletin Aa-156.

Laboratory Service
A new edition of "The Metal Analyst" tells about an organization established by Adolph I. Buehler specializing in the installation of metallurgical laboratories. The complete line of laboratory equipment marketed by Buehler is also catalogued. Bulletin Dy-135.

Nickel-Copper Steels
Exceptional resistance to corrosion and abrasion, increased tensile strength, and higher ductility are the qualities claimed for Youngstown Sheet & Tube Co.'s new series of Yoloy steels. A summary of properties and notes on their characteristics are contained in Bulletin Ox-93.

Heat Resisting Alloys
Authoritative information on alloy castings, especially the chromium-nickel and straight chromium alloys manufactured by General Alloys Co. to resist corrosion and high temperatures, is contained in Bulletin D-17.

Heat Treating Manual
A folder of Chicago Flexible Shaft Co. contains conveniently arranged information on heat treating equipment for schools, laboratories and shops, and also illustrates the several types of Stewart industrial furnaces. Bulletin Ar-49.

Newer Tool Steels
Vulcan Crucible Steel Co. has a complete and attractive catalog listing their full line of tool steels including many special types to meet the modern trends in industry. Bulletin Jy-127.

Testing with Monotron
Shore Instrument & Mfg. Co. offers a new bulletin on Monotron hardness testing machines which function quickly and accurately under all conditions of practice. Bulletin Je-33.

Corrugated Ingots
The Gathmann Engineering Co. has published a new booklet called "Gathmann Ingot Molds — Their Purpose and Design." It illustrates various corrugated ingot contours designed to produce defect-free surface in steel ingots. Bulletin Ay-13.

Port Valves
Diagrams and descriptive matter show the operation of adjustable port valves made by North American Mfg. Co. that are particularly suitable for mediums whose rate of flow is not constant. Bulletin Oy-138.

Photo-Electric Cells
If you are not familiar with the wide field of applications for photo-electric cells and apparatus, send for this very interesting and complete booklet by Pfaltz & Bauer, Inc., covering the original apparatus developed by Dr. Bruno Lange. Bulletin Ca-142.

Micromax Model
A novel publication by Leeds & Northrup Co. has the effect of almost putting a half-size model of the Silver Anniversary Micromax recorder in your hands. Cut to the actual shape of the recorder, it can be opened out and the whole mechanism swung into place. Bulletin Ca-46.

Resistance Wire
A complete catalog of the various types of electric resistance wires made by the Hoskins Mfg. Co. has been issued. Complete numerical data are included on all types, along with some fundamental facts about heating units. A handy, small size 48-page booklet. Bulletin Jy-24.

Centrifugal Castings
Centrifugal casting of stainless, heat and corrosion resisting alloys eliminates impurities and cooling strains and permits thinner and more uniform walls than any other method. This is explained in a bulletin by Michigan Steel Casting Co. Bulletin Nx-84.

Cleaning Rooms
A catalog of designs for blast cleaning rooms incorporating many labor and time saving improvements making the blast room an unequalled mechanical device for low cost cleaning is published by Pangborn Corporation. Bulletin Ca-68.

Ni-Cr Castings
Compositions, properties, and uses of the high nickel-chromium castings made by The Electro Alloys Co. for heat, corrosion and abrasion resistance are concisely stated in a handy illustrated booklet. Bulletin Fx-32.

Rockwell Tester
A revised and completely up-to-date catalog on the well-known Rockwell hardness tester is well illustrated and contains 24 pages. Published by Wilson Mechanical Instrument Co., Inc. Bulletin Ca-22.

The Review
7016 Euclid Ave., Cleveland

Please have sent to me without charge or obligation the following literature. Circle the numbers that interest you. It is important to write in your company or business connection when you return this coupon.

Name ..... Title .....
Company .....
Company Address .....

Col. 1		Col. 2		Col. 3		Col.4	
Mya-117	Ox-11	Aa-29	Ea-21	Ea-19	Da-51	Oy-81	Jy-127
R-167	Oy-145	Ca-83	Ea-71	Ea-45	Da-47	Dc-4	Je-33
R-166	Dy-26	Ay-10	Ea-122	Ea-50	Da-100	Jy-125	Ay-13
Fa-55	Ba-35	Ea-5	Ea-60	Ea-3	Da-63	Ma-120	Oy-138
Dy-123	Jy-118	Jb-44	Ea-8	Oy-147	Da-70	Ba-67	Ca-142
Ea-139	Dy-111	Oy-126	Ea-87	Ea-167	Da-28	Aa-156	Ca-46
Ca-161	Sx-15	Nv-66	Ea-90	Ea-166	Da-165	Dy-135	Jy-24
Ca-131	Ea-110	Ea-62	Ca-57	Oy-43	Jz-12	Ox-93	Nx-84
				Da-163	Ay-37	D-17	Ca-68
				Da-54	Ba-157	Ar-49	Fx-32
					Ar-30		Ca-22

Six Student Groups

The Junior Members' Own Page

796 Junior Members

Why Add Alloys?—Why Sweeten Coffee

By Charles E. Balleisen

[First prize of $5.00 for the best answer to the question "Why are alloys added to steel?" has been awarded to Charles E. Balleisen, whose answer follows. Richard A. Flinn, Jr. has been awarded $3.00 for second prize, and John E. Taylerson $2.00 for third place.]

Before answering the question, "Why are alloys added to steel?" let's talk about a cup of coffee. Some people drink it black, but most add small amounts of sugar and cream. What do the sugar and cream do? The sugar dissolves in the cream and the coffee, and the cream and coffee solutions thoroughly mix with each other. The result is that the flavor and strength of the coffee are tempered and it becomes more pleasing to the taste.

The same things happen when alloys are added to steel. The elements dissolve in the steel and in each other and, when the steel is cast into ingots and becomes solid, some of them are forced out of the solution and the result is a complex mixture of elements and metallic solutions.

Just as the sugar and the cream have separate effects on the coffee, so various elements affect steel in different ways, and as each drinker specifies the number of lumps required to temper the cup to his individual taste, so various users of steels require that the metal contain certain elements in the amounts necessary to meet their conditions.

Briefly stated, alloys are added to enable the steel to withstand conditions which would cause its failure if it were not alloyed.

What are some of the weaknesses of steel that are corrected by alloying?

First, although it is stronger than other metals, the strength of steel can be greatly improved by the addition of nickel. (Steel itself is an alloy of iron which has had its strength increased by the addition of less than 2% of carbon.)

Second, at high temperatures steel loses its strength very rapidly, but when alloyed with molybdenum it will require higher temperatures to soften it.

Third, steel corrodes (rusts) very easily. The addition of chromium and nickel in the right quantities has produced steels that are so resistant to corrosion that they have been called "stainless steels."

Many alloying elements are used to produce steels that can stand service under conditions of heat, shock, heavy loading, and chemical corrosion, in addition to the four which have been mentioned.

Membership Is Awarded As Scholarship Prize

Harold N. Meyer, a sophomore in the Department of Metallurgy, Pennsylvania State College, has been presented with a junior membership in the American Society for Metals.

This membership constitutes a prize given by the Penn State Chapter of Sigma Gamma Epsilon (mineral industries honor scholarship society) to the sophomore in the School of Mineral Industries who has made the highest scholastic average in his freshman year.

The prize consists in a membership in whichever national society is appropriate to the curriculum in which the student is enrolled.

Meyer's membership card and also a copy of Metals Handbook were presented to him in the formal Scholarship Day exercises.

Metallurgist's Work Classified in Three Divisions; Many Opportunities Offered

Requirements for Research, Production and Service Metallurgist Vary Considerably; Graduate Should Determine His Particular Fitness for One of Three Fields

Metal working industries are today looking quite anxiously toward this year's technical graduates for young men of metallurgical training. This field of specialized work is far from overcrowded at the present time, and in very conservatively viewing the future, there will undoubtedly be more and more demand on our colleges for metallurgically trained men.

The art of metal working is definitely becoming a science, and a college graduate of today will find therein many opportunities to challenge his vision, abilities, and training.

The most successful and valuable metallurgist will find quite soon after graduation the *one* certain sphere of metallurgy in which he will do his best work because of particular fitness. Fortunately in most metal industries there are at least three main types of work with which the metallurgist may choose to affiliate himself and probably in only one of which will he grow to full stature. These subdivisions are:

1. Research metallurgy.
2. Production metallurgy.
3. Contact or technical service metallurgy.

For research work we will certainly need a man with a much better than the average technical education, preferably some graduate work in a specialized line. A preliminary training in the practical and commercial aspects of his field is necessary, but only to the point of giving him a proper perspective.

Important as this is, a research man must first be actually fired with the zeal to go further into the why's and how's of phenomena than anyone has gone before. Nothing else should make him happy. He must be satisfied with the gradual development of his problems, nursing them along through adolescence to maturity, and unflinchingly taking an occasional mortality of his ideas and hopes in his stride.

The researcher will be, more than any other of his fellows, an individual worker. His contacts with others are quite important, but largely for the inspiration and encouragement which is given him in carrying on his own individual problems. He is not of necessity the born leader, or the affable mixer.

He is a serious-minded, highly intellectual and clear thinking person—one who is level headed but, at the same time, perhaps touched ever so lightly by the spark of genius. This man is the research metallurgist.

The Production Metallurgist

Let us now look into the requirements for a production metallurgist. His place is essentially on the firing line—charged with the responsibility for successfuly carrying on his everyday work with operating problems. He is constantly face to face with situations allowing him very little time for deep study or opportunity for going to other sources for advice and encouragement.

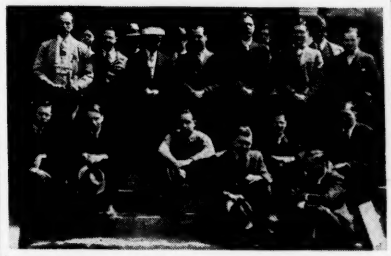
For example, a heat of steel, the carburizing of certain gears, the forming of some difficult cold drawn part, or the smelting of certain ores, is out of line with desired quality or economy, and changes must be made correctly and quickly. The tempo is fast—many problems pressing for immediate answer and not many second guesses allowed.

What sort of a man is this production metallurgist?

Technically educated, yes, of course, but more than that, a man who thinks and acts faster than his problems, a man who inspires the confidence and cooperation of all his associates. His work requires the ultimate in clear thinking, and a very substantial experience which can readily be called

(Continued on page 12)

M.S.M. Men on Trip



Missouri School of Mines and Metallurgy Group on the Steps of the Granite City Steel Works, Granite City, Ill.

The Missouri School of Mines and Metallurgy Group, with Messrs. Hanley, Clayton, Cooke and Walsh in charge, visited several metallurgical plants in the vicinity on April 16 and 17.

The first plant visited was the Federal Lead Plant, American Smelting and Refining Co. at Alton, Ill.

On Friday afternoon Messrs. Solomon, Mohri and Gold, M.S.M. alumni, guided the group through the Granite City Steel Works, Granite City, Ill.

Saturday morning was spent at the Granby Plant of the American Zinc Co. in East St. Louis. The group is planning on frequent trips next fall.

WHY

What is Fatigue of Metals? $10.00 in Prizes

THE REVIEW will pay $5.00 for the best answer to this question submitted by a member of the American Society for Metals, $3.00 for the next best answer and $2.00 for the third best.

Answers should be less than 500 words. They will be judged on the basis of understandability to the layman. They must be technically accurate, yet must be understandable to a person with no metallurgical or technical training.

Mail your explanation to THE REVIEW, 7016 Euclid Ave., Cleveland, Ohio, no later than Monday, June 7. No entries will be returned.

Steel Making Movies Shown

Russell Solomon, '35, metallurgist with the Granite City Steel Works, exhibited a motion picture film before the Missouri School of Mines and Metallurgy Group on April 2.

The picture showed the making of steel from the open hearth through all stages of manufacture, and was highly instructive.

Al Tells Bob About Troostite & Sorbite

"Well, Al, so this is your metallurgy lab—some joint! I should think it would be fun to sit around here and squint at things in the microscope and take pictures of them."

"It is until your pictures don't turn out right. But let's get down to business, Bob. I've got some samples all picked out for you. We'll use this mike

Sorbite

Troostite

and I'll adjust it so all you have to do is turn the thumb-screw to focus the lens. There, now take a look."

"Well, blow me down! This certainly doesn't look much like the pearlite you showed me a picture of. What do you call this?"

"This is known as sorbite and on the contrary, it really is a good deal like pearlite, but it's in a much more finely divided state."

"What do you mean—more finely divided?"

"Do you remember, we said that pearlite is composed of alternating platelets of ferrite and cementite. Well, so is sorbite, but the lamellae are much finer than they are in pearlite. If you look closely, you can just barely distinguish them in this sample."

"Barely is right. Now what makes this different from pearlite? It's the same kind of steel, isn't it?"

"Oh yes, but you know we also found out that pearlite occurs only in very slowly cooled steels. Sorbite occurs when steel is cooled just a little bit faster."

"Yes, and I remember you told me that steels are harder when they are

(Continued on page 12)

1000 Graduates to Find Jobs Open in The Steel Industry

Nearly 1000 college-trained men are expected to find jobs open to them in the steel industry when they graduate this spring, according to estimates made by the American Iron and Steel Institute. Most of them will be from technical and engineering schools.

A number of steel companies have organized plans for recruiting college-trained men, close contacts being maintained with various institutions for that purpose. Likely candidates for jobs are selected from among the graduating classes. Some companies also are planning to offer opportunities for summer training in the mills to under-graduates.

A large majority of the college men choose "overalls" jobs at the outset rather than "white-collar" work.

A survey of the college men hired by a leading steel company during the past 13 years showed that 12% entered the sales department, 3% entered the administrative department, 21% went into metallurgical work, 18% went into the rolling mills, 8% into the open-hearth department, and 9% into combustion and steam departments. Other operating divisions absorbed the rest.

Polariscope Discussed by Two Speakers

Spade Gives Theory of Stress Analysis; Maradudin Results of Polariscopic Study

By Louie W. Mosley

Los Angeles Chapter—Two special attractions were featured in an outstanding program on April 8.

Through the courtesy of the American Iron and Steel Institute the talking picture "Steel" was shown, and was thoroughly enjoyed by all present.

The speakers of the evening, James H. Spade and Alexei P. Maradudin, had for their discussion subject "Polariscopic Stress Analysis."

Mr. Spade dealt with the theory of the polariscope as applied to stress analysis. He first discussed light sources and the types of light adapted to use with the polariscope, a white light, preferably solar light, being the best for this purpose.

Tracing back to the first research work dealing with the polariscope, Mr. Spade explained how Brewster in 1815 demonstrated stress analysis by photo-elasticity with a polarizing crystal, iceland spar.

Incandescent Light Used

Describing his own machine, Mr. Spade stated that he used incandescent light, the nearest practical approach to white light outside the solar source. He explained the light phenomena relating to transparent bodies, known as diffraction, refraction, and dispersion. Diffraction is responsible for the visual effects seen in photo-elasticity.

He stated that his machine consisted, fundamentally, of a condenser lens, a polarizing plate, sometimes called the polarizer, a specimen, and then the final polarizing plate, sometimes called the analyzer.

The problem of finding the best material for the specimen was discussed at considerable length by Mr. Spade, it appearing that no one material is ideal in all respects. Bakelite, celluloid, glass, and marblette were analyzed as to various characteristics.

Mr. Maradudin dealt with the actual results of polariscopic study applied to practice. He stated that the material for their specimens, marblette, was a phenol resin product, and also explained that the results of polariscopic analysis must be taken largely as qualitative rather than quantitative. He mentioned that the projector polariscope demonstrated was the transmission type.

Mr. Maradudin stated that a method of manufacturing polarizing plates such as used in a projector polariscope, by precipitation through a chemical reaction, has been patented, several distinct methods of crystal orientation being covered in the patent.

Analysis Demonstrated

The demonstration consisted of the analysis of a large number of different specimens by means of the polariscope, such as welded shapes, notched sections, assymetrical specimens, and even built-up structures. The comparative stress at any point was indicated by the appearance of color bands at the stressed point, the colors appearing in orderly succession, and repeating the cycle for still greater stresses until the specimen failed or stress was released.

The specimens used were flat, but it was stated that round specimens could be used, also composite specimens, made up of differing transparent materials, to simulate the combination of different materials in actual structures.

The comments and discussion at the conclusion of the demonstration indicated considerable interest.

Refractories Studied Under Microscope Shown in Movies

Rhode Island Chapter—The film "Super Refractories Through the Microscope" was presented by R. A. Barr of the Carborundum Co., Perth Amboy, N. J., at the April 7th meeting.

This movie shows the appearance of thin sections of refractories as they are revolved on the stage of a petrographic microscope under polarized light. The results are striking and illustrate the importance of this tool in research on refractories.

With such a method, the various components of a refractory, or a slag in a closely related field, can be actually determined. Phases present after subjection of the refractory to high temperatures are revealed, and in this way, changes in structure impossible of being discovered by chemical analysis alone can be followed.

While a relatively old tool of the geologist, its adoption by chemists and metallurgists has been recent, and offers great possibilities. As pointed out by the speaker, the improvements in refractories in the last few years could not have been so successfully made without this microscopic method.

Included with the color film was a movie taken with the "thermal microscope," which showed the action of refractories under various types of severe melting conditions. Mr. Barr described the construction of this microscope, and it is most ingenious, because the objective is several feet from the furnace used in the test.

Pieces of different refractories were photographed side by side, as they were, or were not, attacked by acid or basic glasses. In this way, the resistance of refractories to destruction under actual slags can be determined, and shown in a forceful manner.

Not many of the members had previously been introduced to the mysteries of thin sections under polarized light, and they were keenly interested.

Metallurgists Classified In Three Main Divisions

(Continued from page 11)

upon for the proper evaluation of all the factors in entirely different situations.

For example, his is the responsibility to see that his company is making the very best steel possible for a certain customer's requirements, but at the same time showing an economy of operation that warrants his existence.

We also find the production metallurgist quite often called into customers' plants on problems concerning the proper processing of his product. These contacts require a certain proportion of the ability to meet other men and retain their good will under conditions which are often very trying.

The plant metallurgist will also usually have under his supervision many laboratory investigations of a distinctly technical cast which can really be considered as of research character. Usually they are very closely allied with production problems of immediate importance and application as against those of the pure research metallurgist who often will first track down an idea and then later try to find its commercial value. Both kinds of research are of importance, but they are best fostered by different kinds of men.

[The third general field for metallurgists—namely contact or service metallurgy—will be discussed in the next issue.]

Al Tells Bob About Troostite & Sorbite

(Continued from page 11)

cooled faster too, but we still don't have the explanation."

"That has all the earmarks of a dirty crack. But at least I can see you're paying some attention. Anyway, sorbite contains another constituent besides ferrite and cementite."

"Holding out on me, eh! Well, what is it?"

"Wise guy! It's a solid solution of cementite in ferrite, or alpha iron."

"Alpha iron—that's a new one, isn't it?"

"Yes, but we'll talk more about alpha iron when we get to discussing the other structures of hardened steel. Just call it the same thing as ferrite right now and let it go at that."

"Okay, but now what did you say this other thing is—a solid solution of cementite in ferrite? What's a solid solution?"

"Well, you know what a solution of salt in water is, don't you? A solid solution is the same principle exactly. In a solid solution of cementite in ferrite, we get a homogeneous solid like a salt solution is a homogeneous liquid. Grab wise?"

"Yes, I guess so. But say it over."

"Sorbite, you see, is composed mostly of a mixture of cementite and ferrite just like pearlite but in a much more finely divided state. It also contains a certain amount (very small) of a homogeneous constituent that is a solid solution of cementite in ferrite. That ought to be pretty clear."

"Good enough. Now what's next?"

"It's getting late, but I guess we will just have time to show you some troostite. Here, slide this specimen under."

"This is sort of a study in black and white."

"Yes, but we're not going to bother with the white part now. That's martensite, but it's too late today to explain that."

"Then what about the black part?"

"That's troostite."

"Another funny name. Where do they get them anyway?"

"These two happen to be named in honor of the French scientists Troost and Sorby, who did a lot of work on the structure of steel."

"The black stuff in here looks a little like the sorbite we just looked at."

"So it does and so it is. But the steel was cooled a little faster to get troostite, and the ferrite and cementite are even more finely divided and there is more solid solution than there is in sorbite. The mixture of cementite and ferrite is so close to being a solid solution that it is sometimes considered to be colloidal."

"Ah, I do remember what a colloid is. Sort of an intermediate stage between a solution and a suspension, isn't it, Al? I suppose it works the same way in a solid solution."

"That's right. Go to the head of the class."

"Well, I'm beginning to see that the cooling rate has a lot to do with the structure of the steel, but you still haven't thrown much light on hardening."

"How about coming back here again sometime then, Bob? It's pretty late now and there are two more samples for you to see."

"Well, just so we get it cleared up soon, Al. My curiosity's getting the best of me."

WANTED

Used Universal, Charpy or Izod testing machines suitable for cast iron testing. Also used Zeiss or Leitz metallographic microscopes.

Address Box 5-1
American Society for Metals
7016 Euclid Ave. - Cleveland, Ohio

New Impact Tester Developed by Mann Interests Members

By Hugh E. Brown

Cleveland Chapter—Henry J. Chanon of the Nela Park Division of General Electric Co. discussed the work being done by his company in connection with the prevention of accidents by the use of better street lighting, as a coffee talk at the meeting on April 5.

Evidently, judging by what Mr. Chanon says, the accidents from night driving will be reduced more and more as this research work is continued.

After the coffee talk the election of officers for next year took place.

Chairman-elect Gordon Williams announced the appointment of the committee for the Chapter annual outing with R. H. Perry as Chairman.

The technical part of the program was in charge of Prof. H. D. Churchill of Case School. He introduced H. C. Mann, senior materials engineer of the Watertown Arsenal, Watertown, Mass.

Mr. Mann gave a splendid address on "Impact Testing." He described the various methods in use today and included some interesting data on the new impact machine developed by him with the assistance of Captain Haskell of the Ordnance Department.

Final Lecture on Copper

By E. V. Peterson

North West Chapter—The season's final lecture on April 13 featured a talk on copper and copper alloys by H. W. Butterbaugh, technical supervisor, American Brass Co., Kenosha, Wis.

A short film on the metallurgy and working of copper was given prior to the talk. Numerous slides were used to illustrate the effect of alloying elements on copper, particularly with reference to the conductivity.

Cadmium alloys with copper are valuable because they retain a large percentage of the original conductivity in spite of their increased properties.

Employment Service

Address answers care of A. S. M., 7016 Euclid Ave., Cleveland, unless otherwise stated

Positions Wanted

BEGINNER in chemical or metallurgical laboratory. High school graduate. 23 years old. Experience in warehouse work. Has taken some courses in chemistry. Cleveland territory preferred but not essential. Box 5-5.

Positions Open

REPRESENTATIVES for St. Louis, Minneapolis, and Boston territories; manufacturer of pyrometers and auxiliary equipment. Commission arrangement. Will consider men now handling other allied line. Box 5-50.

METALLURGICAL CHEMIST: Manufacturer of automotive parts desires services of young metallurgist with experience in steel strip mill. Must be capable of handling routine chemical analyses and should be experienced in metallography. Experience with copper plating also desirable. Write stating age, education, experience, and salary desired. Box 5-55.

SIX TECHNICALLY trained young men for sales engineering work on alloy bars and seamless tubes. Metallurgically trained men with two to six years experience in steel mills preferred. Past sales experience not essential. Applicants should have the desire to keep abreast of modern developments in ferrous metallurgy and combine same with development and creative sales work. Successful applicants will be given a thorough training in all phases of the company's business, length of training depending on past experience. Box 5-60.

METALLURGIST who has had some experience preferably in steel. Not necessary to have had any real practical experience in steel making but must have ideas about how steel should be made. Must have good personality and able to meet and discuss problems with officials and outside persons. With company whose main work is the production of steel castings. Box 5-70.

YOUNG MAN with metallurgical education, and experience in the heat treatment of steel wanted by a large tractor manufacturer located in the middle west. Candidate must be able to assume technical supervision of a large heat treating department. Man with some production experience preferred. Write stating age, education, experience and salary desired. Box 5-65.

PHYSICAL METALLURGIST with doctorate and some industrial experience in ferrous metallurgy, for staff of eastern college. Candidate preferred with keen interest in research and post graduate work. Box 5-75.